Learning for Sustainable Development. Merging Professional Demands and Academic Standards.

Learning for Sustainable Development

Cover image. Aerial photograph (1 August 2007) of the reclaimed land polder *Hedwige* in the Dutch province of Zeeland, a case study discussed in Chapter 2. The image shows the vast estuarine salt marsh *Verdronken Land van Saeftinghe* of the Western Scheldt. In the background, bordered by lines of poplars, the polder Hertogin-Hedwige with its disputed planned managed retreat of the coastal defences. Belgian territory starts at the 2nd line of poplars (cut in 2008). The built-up area in the far background, behind the cooling towers of the nuclear power plant of Doel, is Antwerp and its seaports near the river Scheldt. Source beeldbank.rws.nl / Joop van Houdt

Learning for Sustainable Development

Merging Professional Demands and Academic Standards

Angelique Lansu

Colophon

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Chapter 1

Introduction

The central question of this thesis is how to design and support learning for sustainable development, taking into account the flexible, changing professional demands which arise from the knowledge triangle and the more rigorous requirements which arise from academic learning in formal curricula. In the present thesis, the point of entry for our studies is the regional knowledge society. Although sustainability issues impinge on all geographical levels, from the local to the global, this thesis focuses on the regional level, the level that tends to act as a focal point for economic, social and cultural activities. We focus on how the regional knowledge infrastructure – the knowledge triangle of private, public and research sectors – may and perhaps should be strengthened by linking it up with traditional players in this infrastructure: institutions for higher education, in particular universities.

Key words: sustainable development, curriculum design, transboundary competence; learning; academic quality assurance

1 Introduction

In this *first, introductory chapter,* we describe the pitfalls, barriers and viabilities of linking theory to practice in education, especially in the domain of sustainable development. The research focuses on how formal academic curricula (learning programme and pedagogy) cope with the rapidly changing demands from the regional knowledge society. The research consists of four explorative studies each of which concentrates on a different aspect of learning for sustainable development. The four explorative studies focus in particular on the design requirements for a learning environment that is oriented towards preparing students to work on sustainable development. They take into account professional demands and academic quality standards by investigating the translation of these demands and requirements into the practice of design and evaluation of curricula and learning models. The final outline section of this chapter briefly describes these studies and refers to the corresponding chapters.

According to the Dutch coalition government agreement, sustainable development is ‘a major driver in the transition to a sustainable economy and green growth’ (Rutte & Samsom, 2012). Importantly, sustainable development can provide innovative power to the regional knowledge society (Adomßent, 2011). This strengthens the competitiveness of the region by sustainable initiatives among the regional knowledge society (also referred to as regional ecosystems), of the private sector, the public sector and research.

It is this regional level (or the meso-level of organisations), which interacts with both the local level of sustainability initiatives (at the micro level of the individual citizens) and the global level of challenges (at the macro level of key stakeholders, politics and society). This is also referred to the regional level of innovation dynamics between the public, private and research sectors (the knowledge triangle referred to already) with its education, research and innovation as the key drivers of the knowledge-based society. Making use of these divergent stakeholder perspectives is vital for dealing with the unstructured policy issues in sustainable development such as the transition to a sustainable energy system (Cuppen, 2010).

To begin with, we will now discuss these perspectives. This then results in a problem statement and some specific research questions. In the chapters to follow we discuss in detail how to translate the requirements to the design of learning opportunities and environments that are fit to the changing professional demands. The resulting guidelines can be used in practice of academic learning for sustainable development.

2 Working in a knowledge society

Working in a regional knowledge society is complex and dynamic. Since the late 20th century, major technological developments - such as the internet - have ensured that knowledge and information are much more easily and more transparently accessible and shared (WRR, 2002). The tasks of workers have shifted from developing and manufacturing materials and products to knowledge activities. Examples of knowledge workers using knowledge as their main capital for the design and manufacturing of products, including the development and provision of services (Sloep & Brouns, 2011; Sloep & Jochems, 2007) are engineers and consultants, who are considered to play a crucial role in innovation (Raes, 2012). What differentiates knowledge work from other forms of work is its primary task of 'non-routine' problem solving, requiring a combination of convergent, divergent, and creative thinking (Reinhardt, Schmidt, Sloep, & Drachsler, 2011). This implies that knowledge workers cannot afford only to rely on their own knowledge, but also have to search for and process knowledge that resides with others. This can take the shape of co-creation, emanating from collaboration with knowledge workers in other domains or from other stakeholders and social groups (social learning). Because of the complexity of the knowledge activities and the need to be reflective, this type of knowledge worker has to be trained at an academic level (Sloep & Brouns, 2011).

Because knowledge generation and knowledge transfer occurs during the interaction between education, research and innovation (van Vught, 2009), there are several domains, in which the professional demands are rapidly changing. If we look at the characteristics of both knowledge work and working on sustainable initiatives, the broad domain of sustainable development should clearly be considered as a case of *knowledge work*. In their frame of reference of academic learning for sustainable development, the Dutch-Belgian Flemish coordination committee on academic environmental sciences programmes ICM-VSNU indicates sustainable development as a manifest object of diagnostic- and solution-oriented research (ICM-VSNU, 2012). It is also seen as being a political-ethical guideline for society-oriented action in academic research (ICM-VSNU, 2012), which implies *participatory interaction* between public and private parties and universities or research institutions. These characteristics of sustainable development, as being diagnostic, solution-oriented, and society oriented, fit in with the 'non-routine' complex problem-solving characteristic of knowledge workers.

Apart from the outlined, cognitive dimension of knowledge working on sustainable development and the social dimension of participatory interaction, an additional, third dimension, is tied up with the *uncertainty* of natural processes and phenomena of system earth (Eden, 1998; Kates, 2010; Kates et al., 2001). Uncertainty in sustainability research refers to a lack of knowledge to describe processes or phenomena in sufficient detail. Because of this uncertainty, knowledge work on sustainable development often will lead to more than one possible outcome or no defined expected outcome at all. Forecasting outcomes may for example be based on back-casting from future goals (Quist & Vergragt, 2006; Vergragt & Jansen, 1993), or on analysis of divergent scenarios and integrated assessments (Millennium Ecosystem Assessment, 2005), or on broad stakeholder involvement in participatory methods (Cuppen, 2010; Quist & Vergragt, 2006). Problems on sustainable development need also to be considered at different levels on the scale, both in time and space (Martens, 2006).

Many of these elements can be detected in the European Grand Challenges as formulated in the EU Framework Program '*Horizon 2020'* (European Commission, 2011) or in the Dutch governmental policy of *'topsectoren'* (economic peak or top sectors) (Ministerie EL&I, 2011; Rutte & Samsom, 2012). With the focus on top sectors, the Dutch government wishes to strengthen the economic domains in which the Netherlands excel worldwide. In their report, *Beyond the horizon of Rio+20,* the Dutch Academy of Science (KNAW, 2012) took stock of the scientific research for sustainable development in the Netherlands. According to the KNAW (2012) the strengths in science for sustainable development within the Netherlands, are located in many scientific disciplines. Existing strengths have led to widely, internationally recognised applications in a number of areas that are crucial to sustainable development. Table 1.1 shows these scientific disciplines, in which in the complexity of knowledge (e.g. multi-and interdisciplinarity), the participatory interaction (e.g. governance), and the uncertainty can be recognized (modelling and assessment). The KNAW (2012) states that given the Dutch top sector policy that is currently being implemented (Ministerie EL&I, 2011), the sustainability orientation is mostly on water, energy, chemistry and life sciences, and health and agrofood; these are in line with the European horizons, the societal challenges for research and innovation (European Commission, 2011). These domains are pertinent to the cases on curricula and courses in environmental sciences and water management, which are studied in this thesis.

Table 1.1 Dutch strengths in scientific disciplines for areas crucial to sustainable development (KNAW, 2012).

Research areas crucial to sustainable development	Scientific disciplines (Dutch strengths) in science for sustainable development
Governance	international institutions, earth system governance, environmental governance, regime shifts, corporate social responsibility, population change and sustainable settlement
Modelling and assessment	climate change, adaptation and mitigation, modelling complex ecosystems, ecological risk assessment, alternative stable states in ecosystems, life cycle assessment and input-output analysis of environmental impacts, ecological modernisation
Water	drinking water and waste water treatment, water management, virtual water footprint, microbiology and biotechnology for water
Energy	biomass gasification and biofuels, impact of biofuels on land use, experience curves in energy, microbiology and biotechnology for energy
Biodiversity	conservation, taxonomy and biogeography, protecting fragile environments
Health and agrofood	socio-economic status and health, infectious diseases, chemical industry, agriculture and sustainability, soil science.

With its multiple objectives and interactions on environmental issues, economic vitality and socio-cultural equity, it seems clear that this search for future solutions on a sustainable development, amongst the various actors in the knowledge triangle, requires a combination of convergent, divergent, and creative thinking across the boundaries of systems, disciplines and methods, science and society, nations and cultures, scales of time and space (de Kraker, Lansu, & van Dam-Mieras, 2007; Lansu, Boon, Sloep, & van Dam-Mieras, 2010). De Kraker et al., (2007) refer to the ability to cross such 'boundaries' as the '*transboundary competence*'. Arguably, it is a competence for knowledge workers on sustainable development. This competence comprises their ability to think, communicate, learn and collaborate across the boundaries that divide the perspectives, analogous with the conclusion that learning of knowledge work requires an academic performance level. We may also conclude from the above arguments that the complexity and the uncertainties of sustainable development demand that knowledge intensive working for sustainable development should be learned at an academic level.

3 Learning in a knowledge society

The need continuously to learn in a knowledge society prompts the question of how and when knowledge work may be learned. We already hinted at this in the previous section. Sloep and Brouns (2011) provide an answer, they concentrate on post-initial learning, the trajectory in which individual workers, supported by their employer or not, take responsibility for their own learning, and thus for their own employability. This so-called lifelong learning, must be organised differently than the formal, school-based learning within a particular domain. Sloep, van der Klink, Brouns, van Bruggen, and Didderen (2011) discuss various studies through which they support their idea that what they refer to as learning networks may offer a solution. Learning networks, they argue, are helpful in both formal and informal learning. In their view, the essence of networked learning is that learners learn to perform their future tasks in (online) connectivity to other learners.

Indeed, this applies equally well to informal and formal settings. We surmise that for large groups of people to arrive at a recognised level of learning, the organisational structure of a formal programme, consisting of a curriculum of courses offered by an acknowledged institution, is the most appropriate solution; e.g. Rikers, de Snoo, and van Dam (2011).

At a regional educational level, we see this need for connectivity between work and learning strongly reflected in formal curricula for vocational and professional training, which have been transformed into competence-based curricula with a focus on competencies determined together with businesses (professional sector), as learning outcomes. Although this transition is accompanied by criticism on the pitfalls (loss of overall expertise through the focus on separate competencies), it operates in curricula oriented on society and professional demands, with didactic models such as project-based learning, work-based-learning and internships.

This connectivity between work and learning is much less present in academic learning in higher education. As already indicated the organisation of learning is in a large measure determined by quality assurance, which is a prerequisite for the accreditation of curricula, the license to offer academic degrees. Formal higher education, matters not only to young adults, following secondary education, but also to professionals willing to upgrade their competencies, since a formal academic degree, a recognised academic qualification in a relevant field is still required for promotion to a higher job position, or migration to another domain or work field (NW, 2013).

Academic university curricula have few opportunities to flexibly suit their curriculum and its didactic underpinning to a well-defined professional sector. Academic quality standards, including academic independence, intellectual distance and critical reflection hamper the close and easy matching of curricula with changing professional competences. Academic standards are incorporated into academic quality assurance frameworks and authorative structures. They are therefore hard to ignore when one seeks to better connect academic curricula to the changing demands of the workfield. However there is a need to do so as the dynamic transitions in the university-industry-government network, the Triple Helix (Etzkowitz & Leydesdorff, 2000), make a strong appeal to knowledge workers once graduated. The integration of the different roles academic professionals have to play in the changing context of their work – academic and professional – is illustrated quite well in Gibbons' notion of mode 2 knowledge production (Gibbons et al., 1994). Mode 2 points to an ad hoc multidisciplinary, context-driven, collaboration on specific problems in the real world.

At the level of curriculum design and didactic models in university curricula, not much research has been done on the alignment between university and the professional field, nor what this means for the learner and the academic programme. In the remainder of this introduction, we examine in a broad sense what pitfalls and barriers stand in the way of this tuning of academic curricula and learning models to the demands of the real world. Obviously, these pitfalls and barriers result from a university organisation that, justly, wants to ensure that its academic quality standards are adhered to the programmes offered.

The problem and solution-oriented character of curricula directed to sustainable development, implies, that in addition to a scientific basis, considerable attention must be paid to the complexity of the problems, the social context, multi-and interdisciplinarity, and (handling) uncertainties (ICM-VSNU, 2012; Kates et al., 2001; NW, 2013). Curricula for sustainable development in higher education should be dedicated to student competence development for decision-making in a future-oriented and global perspective, in connection with knowledge production in regional sustainability initiatives (Adomßent, 2011; Adomßent, Godemann, & Michelsen, 2007; Angeon, Caron, & Lardon, 2006).

4 Problem statement and research questions

In this thesis, we examine what this attuning of academic curricula and learning models would mean (in terms of pitfalls, barriers and viabilities) for the design of university curricula within the organisational structure of the university. In this doctorate research, we concentrate on formal education for lifelong learners, on academic curricula and on courses in formal settings. As we argued the following problems arise:

How may we design and support learning for sustainable development, particularly in the regional knowledge society? How do we cope with the rapidly changing demands from the regional knowledge society pertinent to its innovative power? How could learning activities contribute to the acquisition of the much needed transboundary competence?

The answers to these questions depend on the perspective on learning and the requirements of the learning environment. From the perspective on formal academic learning, we can now limit the questions raised earlier:

The following research questions arise:

How could we design and support the learning for sustainable development within the academic organisational system of quality assurance.

Is it possible, with education as one of the key drivers for sustainable development, to link learning at an academic level – with its rigorous standards and values – to the dynamic practice of the professional demands of the regional knowledge society?

5 Outline of this dissertation

The next chapter, Chapter Two*, Learning in networks for sustainable development,* focuses on the role of universities in sustainable regional development in our increasingly knowledge based society. We describe learning for sustainable development as obtaining the ability to cross the boundaries between multiple perspectives in interaction with stakeholders, shown by a current authentic example on the Dutch-Flemish Scheldt Estuary debate on sustainable water management (managed retreat of coastal defence). The chapter explores how an online remote internship model can effectively support competence development in a heterogeneous professional learning network.

In Chapter Three *Changing professional demands in sustainable regional development*, again, the regional level of this study is the cross-border Rhine-Scheldt Delta and its knowledge network on sustainable innovations in water management. This chapter considers the implications of changing professional demands in the domain of sustainability from the point of view of the university. It addresses the following research questions: How can a university incorporate transboundary competence? And how can the academic quality of learning outcomes be guaranteed in such curricula? Proposed is a design process based on open curriculum development in interaction with the workfield.

Chapter Four *Transboundary competence on sustainable development: a roadmap merging professional demands and academic standards* describes the design of a competence road map, to process curriculum development within the conditions of quality assurance and changing professional demands. Quality assurance for academia is of major importance in establishing the domain, for funding on research and education and for its attractiveness for student enrolment. Therefore the following question is in order: How do these curricula, directed at future-oriented challenges and transition of knowledge in (regional) networks, fit with often strict academic standards? The findings of this research may help identify the main obstacles.

The central question in Chapter 5 *Learning by cooperative knowledge work: dynamics and performances in virtual consultancy teams* is how networked learning and virtual work should be designed to contribute to the changing professional demands in transdisciplinary domains. This chapter reports on the design and the dynamics of learning and working in such virtual consultancy teams in a formal, academic setting. The current Dutch Prime minister Rutte, in his remarks on this work and learning model 'virtual environmental consultancy' (chapter 5), called this connectivity between work and learning '*blended learning*', although this term is mostly used for mixed models of online and face-to-face learning (Rutte, 2005). The chapter takes the vantage point of virtual team performance and discusses computer-supported cooperative work in the context of knowledge work in so-called learning networks, online social networks that have been designed to foster lifelong learning.

Chapter 2

Learning in Networks for Sustainable Development

In this chapter, we argue how learners who have to deal with the kinds of different perspectives of sustainable development will develop their personal competences in an effective way. An authentic example on the Dutch-Flemish Scheldt Estuary debate, described in the present study, shows such different perspectives and how they influence the scientific study of and decision-making on sustainability issues. The present study explores how a didactic model of remote internships allows learners to work in virtual teams on current, authentic research assignments can effectively support competence development in a heterogeneous professional learning network.

Key words: authentic learning, virtual teams, remote internships, sustainable development, formal education, learning network, lifelong learning, Scheldt Estuary
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Abstract

The didactic model of remote internships described in this study provides the flexibility needed to support networked learners, i.e. to facilitate the development and subsequent assessment of their competences. The heterogeneity of the participants (students, employers, tutors) in the learning network provides relevant diversity in expert perspectives. In today's (networked) business environment, ever more collaboration takes place through virtual platforms and tools. *Learning for sustainable development* could profit from the opportunities such platforms offer, as part of it. Taken from the Brundtland Report (WCED, 1987) *sustainable development* is development that "meets the needs of the present without compromising the ability of future generations to meet their own needs". Sustainable development has a high level of complexity, with its need for integration of socio-political, environmental and economic perspectives, its uncertainty in future and its dedication to an enormous range of levels of scale, acting from local to global. Because of the complexity of the concept, the defining of competences and learning outcomes for sustainable development is not easy. Learning for sustainable Development could be described as obtaining the ability to cross the boundaries between multiple perspectives in interaction with stakeholders and actors in sustainability issues. An authentic example on the Dutch-Flemish Scheldt Estuary debate, described in the present study, shows such different perspectives and how they influence the scientific study of and decision-making on sustainability issues. We argue how learners who have to deal with these kinds of different perspectives will develop their personal competences in an effective way. The didactic model of remote internships that we use, allows learners to work in virtual teams on current, authentic research assignments in contact with their customers: real employers in the professional field. Moreover, the didactic model enables learners to define their own activities according to their personal learning goals matching the external requirements of employer and university. This allows our learners - adult distance students at the formal BSc Environmental Sciences programme (Open Universiteit) - to start from their own unique perspectives, having different prior knowledge, in different learning domains and from different professional experiences. The multiple perspectives show themselves in the practice of virtual cooperation with peers and experts from both the academic and professional community. Thus, the present study explores how an online remote internship model can effectively support competence development in a heterogeneous professional learning network.

1 Introduction

The question of how to become competent for sustainable development has triggered educators and designers of curricula ever since the concept of sustainable development was endorsed at the highest political levels in the late 80s. The most-often quoted definition of sustainable development, taken from the Brundtland report (WCED, 1987) is development that "meets the needs of the present without compromising the ability of future generations to meet their own needs." At the Johannesburg World Summit in 2002, society's social structure was incorporated in the concept, which puts it at the heart of the integration of socio-political, environmental and economic sustainability: People Planet Profit, which must be established at local, regional, national and global levels. Moreover, since people have become aware of global environmental problems, such as climate change, global warming and loss of biodiversity, the nature, extent and solution of those problems have become uncertain. These uncertainties exist not only because of the extent of these global issues and the inherent uncertainty of the future, but also because of the profound disagreement among scientists about their magnitude, nature, and underlying phenomena.

The concept of sustainable development has a high level of complexity, with its need for integration of mutually counteracting and/or reinforcing perspectives (socio-political, environmental and economic), its uncertainty (unknown future outlook, unknown nature of problems and phenomena) and its dedication to an enormous range of levels of scale (scales of time and scales of space: acting from local to global). Because of the complexity and diversity of the concept, the defining of competences and learning outcomes for sustainable development is not easy (van Dam-Mieras, Lansu, Rieckmann, & Michelsen, 2007) which makes it even more difficult to design adequate learning modes through the academic curricula (Kastenhofer, Lansu, van Dam-Mieras, & Sotoudeh, 2010). From our point of view, we consider Learning for sustainable development very much directed at the competence to view issues of sustainable development from multiple perspectives (de Kraker et al., 2007). This makes Learning for sustainable development clearly distinct from the main stream, value-oriented *Education for sustainable development* (ESD). This much became evident when de Kraker et al. (2007) reviewed the activities of the Open Universiteit for the United Nations' *Decade of education for sustainable development* (DESD

2005-2014) (UN, 2002; UNESCO, 2007), the worldwide programme directed to integrate Education for sustainable development at all levels of formal and non-formal education and learning. In order to reach the United Nations' *Millennium development goals,* goal #7 'Ensure environmental sustainability' (UN, 2012), how to become competent for sustainable development is one of the major research questions to be solved.

This chapter discusses how learners could gain the competences for sustainable development needed within formal academic curricula. A recent example on the Dutch-Flemish Scheldt estuary debate illustrates the requirements needed to define these professional competences needed in Leaning for sustainable development. It made evident that in order to be able to handle sustainability issues, the different perspectives and expertise of all stakeholders and uncertainties about future developments must be taken into account, in interaction with these stakeholders.

We argue that learning modes in which learners, employers and tutors are in contact with each other and with their (professional) communities could provide the multiple perspectives on the issues. What are the characteristics of such a networked learning environment in which such competences can be developed? Which conditions have to be met in formal curricula? Starting from these conditions, we show the characteristics of a remote internship model from the Open Universiteit, functioning as a networked learning environment.

Finally, we argue that in Learning for sustainable development lifelong learning seems to be a prerequisite, because ongoing change and multiple perspectives, also in time and space, are characteristic for the domain.

2 Learning for sustainable development

2.1 Learning from multiple perspectives: transboundary competence

If we want to study how learners in academic curricula could become competent for sustainable development, we should start to define these competences. However, the term 'competences for sustainable development' is not yet commonly used. According to de Kraker et al. (2007) much is published in the context of education for sustainable development (ESD) on what should be taught and learned in terms of knowledge, skills and values (Corcoran & Wals, 2004; IAU Prague Conference, 2006). Apart from a wide diversity of knowledge topics and a large list of skills, what stands out is a prominent attention to values, to prepare students for a role as 'agents of change'. de Kraker et al. (2007) point out that the notion that there may be a valid diversity in perspectives on sustainable development in society, is strikingly absent. But the need for such diversity is inevitable, given the complexity of sustainability problems and the uncertainties that surround their understanding and resolution. The key competences, then, for academic professionals to successfully contribute to sustainable development will be their ability to think, communicate, learn and collaborate across the boundaries that divide these perspectives. (de Kraker et al., 2007) refer to the ability to cross such 'boundaries' as the 'transboundary competence'. Professionals working on sustainable development issues should be aware of their own limitations, acknowledge the diversity of perspectives and be able to think across boundaries and build bridges between these perspectives. With this in mind, we try to extract these limitations and boundaries, the components of 'transboundary competence' between the multiple perspectives to sustainable development using a current, authentic example.

2.2 An authentic example of multiple perspectives: the Dutch-Flemish dispute on the Scheldt Estuary

In August, September and October 2009, a relatively simple environmental problem on the pros and cons of an artificial levee breach for nature development (in Dutch 'ontpoldering') got full media coverage in both the Netherlands and the Flemish part of Belgium. It escalated in an international dispute in which the Flemish prime minister summoned the Dutch ambassador on August 13th 2009. This debate is a wonderful example of the multiple perspectives on environmental problems in today's pluralistic society.

It influences the scientific analysis and solution of the problem. Furthermore, it shows the need for transboundary competences in Learning for sustainable development.

From a mere scientific point of view, the environmental problem seems to be quite simple. The Western Scheldt ('Westerschelde') is a Dutch estuary at the mouth of the 350 km long French-Belgian Scheldt River and includes the main shipping route to the port of Antwerp, the second largest harbour in Europe. The riverbanks of the floodplain consist of tidal flats and brackish and salt marshes. Because of the floods at high tide (twice a day), these are harsh environments and ecologically the most productive areas of the world; they support large numbers of shorebirds and seabirds, many of which are endangered species. Flanders and the Netherlands both recommitted themselves in the 2005 Treaty to improve the main shipping route. Deepening the river by dredging would give access to world's largest mega container ships. However, deepening the river implies both a broadening of the river floodplain by reaching a natural equilibrium state (imagine a V-shaped river channel) and a pattern shift in the tidal flows twice a day. This deepening and accompanying broadening of the river implies destruction of tidal flats and marshes by abrasion and löss of natural environments and biodiversity. Scientifically, the solution to this loss is quite simple: allocate new areas of land to compensate for this loss of estuarine ecosystems in the Scheldt. These new wetland nature reserves could be located on the landside of the river levees by raising the groundwater level or on the riverside by managed realignment of the old river levees. The 2005 Treaty is clear: the Flemish and the Dutch agreed on a particular quantity of hectares of arable land to be reintroduced to the river floodplain.

This example quite well illustrates that in seeking solutions for an environmental problem, one has to take into account the multiple perspectives of all the stakeholders involved.

Just when river dredging was to start, a legal dispute revealed other, non-scientific perspectives on this environmental problem. The Dutch Council of State, the highest administrative court in the Netherlands, ordered to halt the dredging until more was known about the guarantee of nature compensation. The Dutch government had just refused the artificial levee breach to flood the 300 hectare large agricultural land reclamation, the polder Hertogin-Hedwige, and was still studying alternatives. This refusal was probably an effort to acknowledge the arguments of rural and agricultural voters, who were furious about the loss of man-made polders, dikes and high-quality arable lands. Dutch regional citizens and politicians protested against the destruction of levees, probably because of the emotional remembrance of the catastrophic North Sea Flood of 1953 in which 1836 people lost their lives and considerable damage on properties was incurred (Slager, 2003, 2013). Based on research (described and summarized in Nijpels, Heip, Hulscher, Heijkoop, and Verbree (2008) nature organisations showed that innerdyke wetlands (landside; fresh water) could not compensate for the loss of the ecologically high-valued nature of the outerdyke tidal flats (river side; brackish). According to Kistenkas (2009) the scientific report of Nijpels et al. (2008) functioned as leverage in a faltering process of decision-making.

Table 2.1: The boundaries between the multiple perspectives to sustainable development issues in general, in the example Scheldt Estuary and the related approaches to cross these boundaries when contributing.

Boundaries between	In example Scheldt Estuary	Approach to cross
Systems and subsystems	Estuarine systems (tidal system; endangered habitats)	Systems-oriented
Disciplines	Marine biology, earth system science, legal and political science; governance	Interdisciplinary
Science and society	Common knowledge; Value of nature; Scientific best solution – Societal best solution	Transdisciplinary and participatory
Nations	Belgium; Netherlands	International or transnational cooperation
Cultures	Flemish-Dutch, regional sentiments (Flood Disaster, loss of jobs in harbour or in aquaculture)	Cross-cultural
Scales of space: Local to global	River bank, Polder, Region, Nation, European	Cross-scale
Scales of time: short- and long-term perspectives	Harbour access, Habitat and Sustainable development goals	Future-oriented; back-casting
Technique or methods: conventional and innovative	Innerdyke or outerdyke compensation; man-made levees and reclamation of land or innovative water management	Creative thinking; designing

Note: adapted from de Kraker et al. (2007)

The Flemish politicians interpreted the stop of the dredging as a geopolitical act in favour of their rival, the Dutch port of Rotterdam, which is the largest port in Europe. Antwerp citizens, frightened for the loss of jobs in their harbour, started to boycott the degustation of Dutch mussels, as 'moules frites' an iconic Belgian dish. The row on the 2005 Treaty goes back to sentiments from a distant past: by international treaties set in 1830 the Netherlands guarantee free access to the Belgian harbour of Antwerp, after the – then – Dutch Western Scheldt had been closed for shipping for centuries (see background articles in international news papers: (Smyth, 2009, September 1; van Middelaar, 2009, September 8). It escalated in an international dispute in which on August 13th 2009 the Flemish prime minister summoned the Dutch ambassador. This binational dispute ended with the decision of the Dutch Cabinet[1] to respect the 2005 Treaty and to allocate the Hertogin Hedwigepolder as a nature compensation area.

Table 2.2. Multiple, opposite perspectives on the Dutch-Flemish Scheldt estuary debate in the news media headlines on October 10th 2009, after the Cabinet Decision.

	National, Belgian-Flemish (1) Daily newspaper De Standaard *Polder remains dry until 2012*.	
Regional, Rural/Agricultural (4) Daily newspaper Agrarisch Dagblad, *Dredging starts in February*. (5) Daily newspaper PZC *Downright disappointment, it (the protests to keep the polder dry) did not work out.*		Regional, Nature (2) Provincial magazine zeeuwselandschap.nl *Cabinet Decision Western Scheldt good for nature, ...*
	National, Dutch (3) Daily newspaper NRC *Hedwigepolder under water anyway.*	

Source: (Newspaper headlines, 2009, October 10)

Table 2.1, adapted from de Kraker et al. (2007), shows the major boundaries to be crossed when contributing to the understanding and solution of sustainable development issues, along with the approach needed to overcome them. In the table, 'transdisciplinary' refers to working with knowledge from outside the academic arena, 'participatory' to working in interaction with societal actors or groups (van Dam-Mieras et al., 2007).

In addition, the debate in the newspapers shows all aspects of transboundary competences for sustainable development. Both the papers' headlines on October 10th 2009 (Newspaper headlines, 2009, October 10), Table 2.2, and the evaluation research (Nijpels et al., 2008) underlying the decision show the borders between discipline, societal groups, nation, and culture. The example also shows another aspect of Learning for sustainable development: the

[1] This decision was taken twice: on October 9, 2009 and after withdrawal in 2011 again on December 21, 2012

need to work in a transdisciplinary and participative fashion, in interaction with all actor groups or stakeholders involved.

A remarkable difference, which clearly shows the diversity in cultural, national and scientific views in the dispute, is the Babylonian confusion in the search for outerdyke or innerdyke nature areas. Although monolingual – both Flemish and Dutch people use the Dutch language – they do use these terms in an opposite meaning (Schelde InformatieCentrum, 2009, October 22). Whereas the Flemish innerdyke areas are situated along the riverside of the river dikes, the Dutch innerdyke areas are situated just opposite, along the landside of the river dykes. This really confuses the binational debate on the allocation of new nature reserves. The perspectives are not only metaphorically but also literally opposites. To understand the difference, one must show transboundary competences and the ability to change perspectives: just comparing the Flemish fluvial point of view (from headwaters to mouth) with the Dutch coastal defence 'dry feet' point of view (from land to river.

3 Learning in networks in formal education

3.1 Learning environments for learning for sustainable development

Such an authentic situation as the Dutch-Flemish Scheldt Estuary is an ideal learning environment to develop transboundary competences, as one is confronted with the various perspectives in which stakeholders handle the sustainable development issues. The characteristics of learning environments in which transboundary competences can be developed must meet the approaches mentioned in Table 2.1, from system-oriented to creative thinking. Using such approaches, future professionals learn to recognize, cope with and cross these boundaries. Because each learner will start from its own unique perspective - having different prior knowledge, in different learning domains and from different professional experiences - the actual learning trajectories will vary among students.
Below we list the main characteristics of learning environments that are suitable for the development of transboundary competences.

Multiple perspectives: The approaches mentioned in Table 2.1.

Reflection: Learn to be aware of and recognise one's own perspective and that of others in authentic situations.

Interaction (heterogeneous teams): Confrontation with and learning from other perspectives asks for interaction with others; A heterogeneous group of learners will encourage each learner to approach a question from his or her own perspective and area of strength; this will add to the knowledge of the whole group.

Lifelong learning: Boundaries between domains and perspectives will continuously change over time.

Relevant characteristics of communities of lifelong learners are:

Heterogeneity as to age, gender, study time available (dayshifts), professional background (profession; industry); professional development (prior profession); other communities.

Flexibility as to time, content, entry requirements, instructional approach and resources, delivery and logistics (Collis & Moonen, 2001); revised from (Collis, Moonen, & Vingerhoets, 1997).

Lifelong learning is especially relevant in the context of learning for sustainable development. The high complexity of the professional field and the quick turnover of knowledge and insights make learning on a continual basis necessary. In a networked learning environment, it is important to have a heterogeneous group of students working together (Lindfors, 2006). Working in heterogeneous teams better removes participant biases than does working in homogeneous groups (Convertino, Billman, Pirolli, Massar, & Shrager, 2008) although attention has to be given to the phenomenon that socially connected members in heterogeneous teams tend to focus on maintaining their social connections by contributing the knowledge possessed in common rather than on sharing the knowledge they uniquely possess (Thomas-Hunt, Ogden, & Neale, 2003). Explicitly using the unique expertise of learners (prior knowledge gained from prior study and prior and actual professional practice) could overcome this focus on social connections.

Effective collaboration models in virtual teams working in multinational companies differ from onsite collaboration experiences (Dekker, Rutte, & van den Berg, 2008). Dekker et al. (2008) stated from prior research that some behaviours that are found in virtual teams have not yet been covered in frameworks of face-to-face interactions. Study of critical interaction behaviours among collaborating people in global virtual teams, reveals that extra attention is needed for cultural differences. In the findings of Dekker et al. (2008) this is also true between Belgian-Flemish and Dutch national cultures. The same critical interaction in Flemish-Dutch collaboration we have shown in the Scheldt Estuary example given above, although the stakeholders involved speak the same, Dutch language.

4 Remote internships: an effective learning network?

4.1 Remote internships: competence-base learning and working

Following de Kraker et al. (2007) competence-based learning and context-embedded production of knowledge represent an ideal match for sustainable development education. In recent years, the School of Science at the Open Universiteit (OUNL) transformed its academic distance-education programmes in Environmental Sciences. It did so in order to give competence-based programmes in e-learning much more emphasis and to meet both the needs from society for transboundary competences and up to date academic standards. At the end of the Bachelor programme, students of the OUNL carry out their Bachelor thesis work in a collaborative and interdisciplinary research project in a remote internship format (Ivens, de Kraker, Bitter, & Lansu, 2007; Lansu, Löhr, & van Dorp, 2009).

The remote internships last a full academic term, during which learning and working experience are fully integrated in the distance-learning environment. Students work in teams on authentic research questions on behalf of companies or organisations in the Netherlands and Belgium. Within the academic standards of the university and conform the specifications of the employer/client, the student teams give expert advice on environmental and sustainability issues. These advices are delivered as authentic products such as consultancy advice reports based on scientific research. Students work and learn in mutual interaction with their fellow-students (within their teams), with their mentor at the company or organisation, and with their tutors at the university. The focus on individual competence development according to the personal development plans of the students is unique, as is the 10 years – sustainable – experience we have gained with this form of training. This remote internship format is designed as a virtual company, described in (Westera & Sloep, 1998; Westera, Sloep, & Gerrissen, 2000) integrating learning and working in networked learning cycles of personal and professional development. After a pilot track among students in 1998, the remote internship format is slightly adapted on regularly basis, but still running in its key educational design (Ivens et al., 2007). Student data on the years 2000-2009 of this collaboration model are at hand[2].

4.2 A reconnaissance study: first results

How to develop transboundary competences in networked learning on authentic sustainable development issues is the central research question in assessing the data collected from the remote research internships at OUNL.

From 2000 on, the learning environment was supported by web-based collaborative groupware ®EMC Documentum eRoom (2009) which made is possible to (re)design the learning environment via a rapid prototyping process and to archive the experiences of the students and tutors using the learning environment as their online workplace. Each semester, a couple of virtual teams starts working on authentic problems provided by external companies or organisations and delivers their thesis reports (at Bachelor of Science level) as research-based advices. The use of ®EMC Documentum eRoom (2009) made it relatively easy to archive learner characteristics and learner evidence on personal and professional development, from the student's application and project definition to evaluation, certification and BSc graduation.

Working, learning and meanwhile educationally (re)designing the didactic model take place in the same learning environment. During the years 2000-2009, 135 students applied for a remote internship, which they concluded with a BSc thesis. The number of certified students compared to the total number of applicants over the period 2000-2009 is very high: 89.6%, also the grades were high. This suggests a high effectiveness of learning and a high motivation of students. All (100%) of the certified students end up with a formal diploma in the BSc programme (propedeuse, short cycle, BSc).

Generally, virtual teams of 2 to 4 students, worked collaboratively on the online remote internship projects. These were heterogeneous teams, according to the heterogeneity of the students certified over the period 2000-2009 (18.5% Flemish, 81.5% Dutch; 37.0% female and 63.0% male) or more in detail (6.7% Flemish female, 11.8% Flemish male, 30.4% Dutch female; 51.1% Dutch male). There is no difference between the 8.1 % students, which had

[2] An analysis of student data 2000-1012 of the collaboration model described will be presented in Chapter 5.

to finalize two different remote internships in two separate semesters (completing the whole BSc study; no prior conventional bachelor education) and the group of students (91.8%) who had to follow only a single remote internship, because of prior diplomas (mostly professional bachelor diplomas in biomedical analysis, environmental management, chemistry or other related domains).

As we discussed earlier in this chapter the heterogeneity of the group of remote internships by virtual teams is an important factor enriching the learning process. Looking at the characteristics of the students involved, different dimensions of heterogeneity can be found. To illustrate this point we use the data on the semester track 2008-II (august 2008-april 2009) containing 14 students. This is a representative subset of the population over the period 2000-2009. 12 students of this group received the certificate. At the start of the track they differed in the availability of the time for the study, ranging from 15-10 dayshifts (4) to 9-5 dayshifts (7) to less than 5 (3). [Two Dutch male applicants left the internship prematurely for personal reasons). One Flemish female left the team in the final month due to collaboration constraints, but finished a separate work package of the project].

The first dimension of heterogeneity is age. Mean age at enrolment of the applicants is 36, ranging from 23 to 45. Looking at gender, 6 out of the 14 students were female. The group consisted of 9 Dutch students and 5 Flemish students.

Heterogeneity in terms of professional and educational experience can be demonstrated when we look at the industry sector in which students work and their actual jobs. Only 2 students worked in a sector directly related to the environmental sector (directorate general of water management and environment consultancy), the others were employed in such diverse sectors as education (2), municipalities (2), pharmaceutics industry (2), academic medical centre (2), farm (1), automobile industry (1). Their jobs ranged from youth coach, data manager to advisor on water management plants. It is interesting to notice that during the study, 11 of the 14 students changed jobs; 5 of them went to a job that was directly related to the environmental sector (e.g. nature management, biology teacher, environmental safety coordinator).

Finally, belonging to various networks is an important factor in heterogeneity. Obviously almost all students indicated that they belong to their family networks, having families with children, but they also indicated their relation to other communities on themes as youth working, rural spatial planning but also musical productions.

5 Conclusion and outlook

The didactic model of remote internships offers students a learning environment with characteristics similar to those of a *learning network*. Koper (2009) defines a learning network as a technology supported community of people who are helping each other to better understand and handle certain events and concepts in work or life.

If we consider the more ‘narrow’ definition of learning network by (Sloep, 2008, 2009) many characteristics of the remote internships model are quite similar. Sloep (2009) points at the diverse and overlapping communities in an online social network design to support non-formal learning and professional development. The remote internship didactic model emphasizes the interaction between different communities, i.e. the employers network, the academic community and the professional network contacts of their fellow learners, because of the clearly designed communication structures (tools, reviews) and assessment structures on personal and professional development (Lansu et al., 2009; Löhr & Lansu, 2008). Although directed to formal learning, the characteristics as described in section 4 show the importance for learners of heterogeneity, flexibility and the interaction on multiple perspectives, as didactic model to gain transboundary competence and – in the mean time – to enhance and enlarge their lifelong learning network.

The results of the exploration of the characteristics of the applicants who successfully finalized a semester track of the bachelor internship course, shows the heterogeneity needed to support the learners in this online, distributed community. This community of learners does support the students in handling sustainability issues, as it guarantees the heterogeneity and multiple perspectives on the issues needed to develop transboundary competences. At the same time, the heterogeneous teams of students working in interaction with professionals - the employers outside the academy and the university tutors – could be seen as the onset of a learning network, not only within the formal educational programme but also as a non-formal community supporting the transfer of new knowledge and innovative methods relevant to the personal professional development of these adult learners. The flexibility of the academic programme seems to be successful in supporting personal professional development, because a majority of the students has developed the professional career during their study.

In the near future, we will study the results of 10 years networked learning for sustainable development by assessing the available data on learners and learning evidence. We are looking for information on whether heterogeneity in online working in virtual teams supports (professional) learners and helps them to create learner networks, first within formal educational programmes, later perhaps beyond those.

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Chapter 3

Changing professional demands in sustainable regional development:

A curriculum design process to meet transboundary competence

This chapter considers the implications of changing professional demands in the domain of sustainability from the point of view of the university. It addresses the research questions: How can a university incorporate transboundary competence in its view on learning and curriculum development? And how can the academic quality of learning outcomes be guaranteed in such curricula designed to meet the needs of stakeholders? Proposed is a design process based on open curriculum development in interaction with the workfield.

Key words: sustainable regional development, transboundary competence, open curriculum design, networked learning, professional competence, water management, Rhine-Scheldt Delta
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Abstract

Within a region, public sector organisations, private sector organisations and knowledge institutions all have a stake in finding novel ways to face tomorrow's demands. In this chapter we focus on the enhanced role of universities within the social network of our increasingly knowledge based society. The regional level of this study is the cross-border Rhine-Scheldt Delta and its knowledge network on sustainable innovations in water management. The challenge of sustainable development implies a frequent crossing of boundaries between disciplines and stakeholder perspectives and leads to what is called transboundary competence. This chapter considers the implications of changing professional demands in the domain of sustainability from the point of view of the university. It addresses the research questions: How can a university incorporate transboundary competence in its view on learning and curriculum development? And how can the academic quality of learning outcomes be guaranteed in such curricula designed to meet the needs of stakeholders? Proposed is a design process based on open curriculum development in interaction with the workfield. The design process has been tested in the design of a blended learning Master in Delta Water Management.

1 Introduction

Our society can be seen as a global networked society in which the regional level is increasing in importance. Regions have an optimal size for communication and learning for sustainable development in a multi-level system (Adomßent, 2011; Castells, 1996): it is the regional level (or meso-level of organisations), which is in interaction with both the local level of initiatives (at micro level of the individual citizen) and the global level of challenges (at the macro level of key stakeholders, politics and society). Within a region, public sector organisations, private sector organisations and knowledge institutions have a stake in finding novel ways to face tomorrow's demands. The implications and scope of regional development may vary according to the geographic region and to how its boundaries are perceived internally and externally. The regional model of innovation dynamics between the public, private and knowledge sectors is often referred to as the 'knowledge triangle', although the term is not always quite clear as to the three actors involved and the aim of the interaction processes. The so-called and widely-used knowledge triangle of the EU innovation agenda (van Vught, 2009) refers to education, research and innovation as the key drivers of the knowledge based society. Another concept based on mutual, networked learning in strengthening innovation dynamics is the Triple Helix model (Etzkowitz & Leydesdorff, 2000). The triple helix represents the more overlapping, intensive interrelationship between academia, government, and industry as shareholders in regional development. Whereas the triple helix is rather focused on academic business and the commercialization of the results of research processes, in Burton Clark's 'entrepreneurial university', more attention is paid to teaching and learning (Clark, 2004, 1998). To sustain knowledge change, the latter concept blends care for academic values in well-endowed curricula, meanwhile interacting with the dynamics of the professional practice (Clark, 2004). Starting from this theory, the 'third mission' of universities on regional economic and social development is not only to meet the widespread need to generate knowledge-based innovation (Etzkowitz, 2003), but also to incorporate within the curricula a triple helix process of mutual, networked learning. Zilahy and Huisingh (2009) highlight the complex nature and barriers of university cooperation in such multi-disciplinary, multi-stakeholder regional sustainable development initiatives.

In this chapter, we focus on the role of academic curricula in sustainable regional development in our increasingly knowledge based society. The level of study is the Rhine-Scheldt Delta region: a cross-border estuary area in the western part of Belgium and the Netherlands. The process of mutual, networked learning among public, private and knowledge sectors in this region can be defined as transitional learning to overcome discontinuities caused by boundaries and sub-dynamics of innovation (Lansu et al., 2010). Such an engagement in regional learning has of course consequences for the way university curricula are designed. The latter is especially true for curricula on sustainable development, where fostering transdisciplinarity and stakeholder collaboration (Lozano, Lukman, Lozano, Huisingh, & Lambrechts, 2011) and learning to cope with uncertainty and complexity at various levels of spatio-temporal scale are of vital importance.

At the regional level, stakeholders involved in the triple helix will have to discover in mutual interaction what works and what actions are needed. That is why professionals working on technological, environmental, economic, or societal solutions for sustainability problems (Lozano, 2008), have to cope with a continuously changing labour market and continuously changing professional demands. This of course must have implications for the design of curricula on sustainable development in higher education. This chapter reviews the design process of a university curriculum within the triple helix of government-industry-academia, to suit these changing demands into regional curricula for lifelong learning at master level. We will now illustrate such changing professional demands, with examples from water management as a domain in sustainability science.

Current examples in water management show that the professional demands in this domain are rapidly changing. Research on the role of professionals (Hutchins, Annulis, & Gaudet, 2008) during the Hurricane Katrina disaster in 2005 showed the necessity of role change in water management. The Katrina storm surge caused most (2/3) breaches in human designed levees, flooding ‘safely’, water-managed residential areas (ASCE, 2007). Learned from the effects of the Katrina disaster, the prospect of more severe hurricanes, as an effect of climate change with higher chances on levee failures, demands new solutions in this domain. In the search for those solutions not only water managers but also policy-makers, citizens and stakeholders are involved. In sustainable water management, building higher levees is no longer the ‘one and only’ (technological) option. The post-Katrina American practice of water management now focuses on predicting disasters and mediating by 'building with nature' the effects once they have happened (van Koningsveld, Mulder, Stive, van der Valk, & van der Weck, 2008): a role change of the water management professionals. Bijker (2007) noticed that the Dutch water managers seem still merely aimed at keeping the water out. Picture this as the water manager in the role of the iconic Hansje Brinker who plugs a dike with a finger. In her study, Wesselink (2007) analysed the response of this post-Katrina American practice of water management on Delta Water Management in the Netherlands. She concludes that the challenge is to find solutions that are consistent with local and regional culture, and to avoid locking-in whether technologically or politically. Addressing this challenge, the professional demands on Dutch water managers will change.

The example demonstrates that the professional demands for water managers change over time and over space and so does the role, sustainability professionals have to play in interaction with citizens and policy-makers. If entrepreneurial universities want to incorporate such continuously changing professional demands into their academic curricula, they have to translate these demands into intended learning outcomes.

2 Changing professional demands in university curricula

2.1 Professional demands and learning outcomes

The focus on learning outcomes in university curricula is relatively new. Since the early nineties, higher education in The Netherlands and Flanders has been changing from a mainly input-based approach (completion of pre-described study-load) towards a more competence-based approach (NVAO, 2003). This implies an emphasis shift from the learning process to learning outcomes (Felder, Brent, & Prince, 2011). Therefore, the learning outcomes become the measurable goals of the expected level of competence. In competence-based learning, the delineation of learning outcomes is often done by unravelling the job domain in separate key competences, skills, and attitudes. If these are generic qualities related to the potential contribution of the graduate to society and the labour market, the Australian educational system speaks of 'graduate attributes' (Barrie, 2006; Byrne, Desha, Fitzpatrick, & Hargroves, 2010; Desha, Hargroves, & Smith, 2009), a term followed in other educational systems (Avard & Zenios, 2012). Current critiques point at the disadvantages of this kind of competency-based learning and generic graduate attributes. According to Koper and Tattersall (2004), this decomposition of job tasks is a behaviouristic approach, which leads to endless lists of very small, pre-described learning objectives. Following Gonczi (1999) and Schlusmans, Slotman, Nagtegaal, and Kinkhorst (1999), they state that learning design should be based on an integrated competence-based approach that takes a more holistic, less detailed view, because competence has to be used in various combinations to undertake occupational tasks professionally. Barrie (2006) signalling that the present lists appear to mean very different things to the individual academics, suggests to overcome inconsistency in curricula, a dialogue between academia, learners, employers and society before identifying 'central achievements of a university education'. According to Eraut (2004), lists of competences based on the analysis of job tasks are situation-specific, although they can contribute to general understanding within an occupational domain. Also van Merriënboer and Kirschner (2007) point at the necessity for a holistic approach in instructional design, especially for complex learning and whole-task sequencing. This means that learning is not divided in different compartments, but that students are offered whole tasks, in which they are confronted with the total complexity of a problem. While the learner is progressing in the study the level of complexity rises, not its scope. According to van Merriënboer and Kirschner (2007), in ill-structured and complex domains with quick changes of acquired knowledge, professionals should be prepared to deal with continuous changes in their working environment and should be able to direct their own lifelong learning. Eraut (2004) describes competence as a moving target: “what counts as competence will change over time as practices change and the speed and quality of work improves”. He therefore prefers a definition of ‘competence as meeting people’s expectations’, instead of an individual-centred definition in terms of personal qualifications. His definition implies a holistic rather than a fragmented approach to knowledge, and leads to a learning environment in which the ‘apprentices’ are expanding their competence through a combination of peripheral participation and coaching (Eraut, 2004). In their analysis of the instructional design domain, Leigh and Tracey (2010) found that such a holistic need assessment of professional demands is often missing. This prompts new questions: if a university focuses on complexity and continuous change in the professional practice of sustainable regional development, how then can learning outcomes be defined? And how can the academic quality of education be guaranteed in curricula designed for professional performance in the region? Current challenges for higher education policy is to connect the traditional focus on education and research with the grand challenges for a more sustainable world, UN Decade (UN, 2002), Europe 2020 (European Commission, 2011), as a ‘third mission’. To keep up with these changes, curricula have to consider innovative sustainable ideas and regional needs, as well as responses from various, public and private stakeholders. Traditionally, the influence of the regional demands and its labour market on most curricula in universities was rather low; professionalism was defined as ‘academic quality in the disciplinary research work’. Faculty, the academic staff involved in both research and education, guaranteed the inset of professionalism (Steinert, Cruess, Cruess, & Snell, 2005). The prevalence of purely academic criteria for the development of curricula, changed recently by the introduction of external, authoritative bodies who assess the quality of learning outcomes and curricula of universities. They do so according to frameworks for joint quality standards for curricula in higher education. Examples are the American system of ABET criteria for engineering curricula (Felder & Brent, 2003; Felder et al., 2011; Shuman, Besterfield-Sacre, & McGourty, 2005), the Australian generic ‘graduate attributes’ (Byrne et al., 2010; Desha et al., 2009) and the similar

European qualification framework of the Bologna process (Bergen Conference, 2005; ENQA, 2009). The latter describes, based on the Dublin Descriptor criteria (JQI, 2004) (Table 3.1) the academic, generic standard of learning outcomes of the differentiating cycles of higher education. However, in a number of countries academic curricula require complicated conditions and decisions made at the central-governmental or central-institutional level. Hence, coping with changing curricula should account for the hidden, institutional side especially in the global field of sustainable education (Rikers et al., 2011). By indicating the main obstacles, this study explains how one could cope with these conditions in the implementation process of the new curricula design. It departs from the national implementations of the joint European qualification framework for the Netherlands (NVAO, 2003, 2011).

Table 3.1. Quality standards for higher education: the European Dublin Descriptors and their criteria at Master (2nd cycle) and Bachelor level (1st cycle) (Bergen Conference, 2005; JQI, 2004).

Dublin Descriptor	Level (= cycle)	Quality standard (differentiating Dublin Descriptor criteria between cycles)
Knowledge and understanding	Master (2nd)	Have demonstrated knowledge and understanding that is founded upon and extends and/or enhances that typically associated with the first cycle and that provides a basis or opportunity for originality in developing and/or applying ideas often in a research context.
	Bachelor (1st)	Have demonstrated knowledge and understanding in a field of study that builds upon secondary education and is typically at a level that, whilst supported by advanced text books, includes some aspects informed by knowledge at the forefront of their field of study.
Applying knowledge and understanding	Master (2nd)	Can apply their knowledge and understanding, and problem solving abilities in a new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.
	Bachelor (1st)	Can apply their knowledge and understanding in a manner that indicates a professional approach to their work or vocation, and have competences typically demonstrated through devising and sustaining arguments and solving problems within their field of study.
Making judgements	Master (2nd)	Have the ability to integrate knowledge and handle complexity, and formulate judgments with incomplete or limited information, but that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgments.
	Bachelor (1st)	Have the ability to gather and interpret relevant data (usually within their field of study) to inform judgments that include reflection on relevant social, scientific or ethical issues.
Communication	Master (2nd)	Can communicate their conclusions and the knowledge and rational underpinning these, to specialist and non-specialist audiences clearly and unambiguously.
	Bachelor (1st)	Can communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.
Learning skills	Master (2nd)	Have the learning skills to allow them to continue to study in a man self-directed or autonomous.
	Bachelor (1st)	Have developed those learning skills that are necessary for them to further study with a high degree of autonomy.

2.2 Transboundary competence

As sustainable development can be seen as a process of change this entails the need for learning which occurs across the boundaries of institutions, literacies and practices: 'environmental meta-learning' (Scott & Gough, 2003). This process takes diversity as its point of departure because the broad spectrum of perspectives on sustainable development will constitute a successful strategy for coping with uncertainties and change (Ferrer-Balas et al., 2010; van Dam-Mieras et al., 2007). Such a process implies a frequent crossing of boundaries between disciplines and perspectives and leads to what is called ‘transboundary competence’. Transboundary competence is the ability to communicate and collaborate across traditional boundaries, while working in interaction with actors/stakeholders (de Kraker et al., 2007). Transboundary competence is a multi-competence including the communication competence, collaboration competence and competencies that enable people to deal with different situations (expectable as well as un-expectable) in their professional lives. It mirrors the nature of sustainability science (Kates et al., 2001), which is transdisciplinary and uses various methodologies on the boundaries of the triple helix. These boundaries to cross were analysed in the context of the current transnational debate on water management in the Dutch-Belgian Scheldt Estuary (Lansu et al., 2010). Boundaries identified are between systems, disciplines, science and society, nations, cultures and scales of space and time, so between the multiple perspectives on sustainable development issues. These approaches to cross these boundaries should be system-oriented, interdisciplinary, transdisciplinary and participatory, inter/transnational, cross-scale, future-oriented, creative/ design-oriented (de Kraker et al., 2007) and entrepreneurial (Felder et al., 2011). The professional field in sustainable development needs academic professionals equipped with these transboundary competences (Kastenhofer et al., 2010). Experts with their professional expertise are essential in these domains “where there are no right answers”. Expert decision makers have been found to use strategies such as reliance on group feedback, willingness to make adjustments to overcome effects of cognitive limitations (Shanteau, 1988). In their synthesis of the development of expertise in engineering education, Litzinger, Lattuca, Hadgraft, and Newstetter (2011) indicate that the curricula are often not designed to allow learners to prepare for these professional competencies, both knowledge and skills, needed to address the complex problems and preparing students to become experts.

The transboundary competence described above may be needed for regional sustainable development, but how can a university incorporate it in its view on learning and curriculum development? The usual methods appear to fail to do so. Academic curricula are designed with certain demands on professionalism in mind, but in a domain such as sustainable development, the reality is that professionals and academics often find it difficult to articulate what they might need graduates to be capable of in the near future (Lozano et al., 2011). Sustainable development is directed to processes of change in the context of complex and uncertain futures, with unknown problems on a variety of scales. To educate for a rapidly changing professional field, the university and the professionals should jointly and consciously design curricula (Arlett, Lamb, Dales, Willis, & Hurdle, 2010). One cannot define transboundary competence by a definite list of skills, as it depends on the unpredictable complexity of future problems. Transboundary competence should also be seen as a transferable competence that can be applied in professional situations different from the specific situation in which it is learned.

This chapter outlines a methodology for giving the changing professional demands from the domain of sustainable development a place in university curricula. The methodology of the design process aims to be a method for fine-tuning between the different institutional systems and traditions and the professional demands in the region. In the design process, proposed in this chapter, the triple helix of complex dynamics of innovation (Etzkowitz & Leydesdorff, 2000) is related to the integration of the different roles professionals have to play in the changing context of their work.

In the next section (section 3), we elaborate on the design process to suit professional demands for sustainable regional development in university curricula. In section 4, we describe the methodology of such a design process, with participation of the professional field, the academic professionalism, and external quality assurance. In section 5, we consider the case of the recent application of the design process to academic curricula for adult distance education. It was applied in the concrete case of curriculum design for the sustainability domain of Water Management. We conclude section 5 with some points of discussion and main obstacles on incorporating professional demands in university curricula.

3 Requirements of the design process

According to Litzinger et al. (2011), curriculum-level instructional design processes should be used to implement the development of professional expertise, thus meeting the professional demands in those domains, where expertise is essential. In this study, a design process was developed which allows to optimally fit into university curricula, the changing professional demands of the sustainable development domain. The process takes the following guidelines as points of departure. First, the curriculum design should be directed towards the acquisition of transboundary competence. Second, competence development should be a holistic rather than a fragmented approach; what counts is that professionals have to adapt to roles and that competences will change over time in sync with the changes in society and professional practice. At third, Eraut's (2004) conception of competence as meeting people's expectations, the professional experience of academic workers in the domain should be adopted as definition of competence development. Fourth, to be able to connect curricula of the 'entrepreneurial university' (Clark, 2004) to the demands for professional expertise in the domain, one should be aware that 'even in an era of 'globalization' territorial dependencies and strategies remain a dominant factor' (Oinas & Lagendijk, 2005) in regional development. Participation of the professional field in the design process should reflect the complexity and diversity involved in proximity of the regional economic activity. Fifth, to be able to extract learning outcomes from professional demands, the professional, academic experience of the faculty (domain educators) should be incorporated. And finally, universities offer programmes for formal learning, in the form of curricula. A curriculum design embodies the objectives of the formal learning programme as well as the learning outcomes of the programme. The curriculum must fit within the higher-level framework of the (governmental and/or institutional) accreditation authority, to ensure recognized qualifications.

4 Methodology of the design process

In this section, a design process is presented that meets the described requirements, applied to the concrete case of curriculum design for sustainability science. The resulting curriculum must enable learners to develop ‘transboundary competence’ as extracted from the regional professional demands on the one hand, and deal with established criteria for academic quality and complex learning on the other.

4.1 Identifying professional demands by consultation of professionals

The design process is structured as an expert meeting: a university-moderated consultation of professional experts in the sustainable development domain of work organised along with the professional networks. As we cited Mieg (2009), the establishment of professional performance criteria is a task of the experts in the very heterogeneous domain of environmental experts. Mieg (2009) concluded that in these domains, other than in ‘established’ occupational sectors, the experts are the professionals: those who are setting the standards and those who hold jobs. Therefore, the invited experts should be heads, coordinators, process managers, and human resource managers of firms, institutions, and organisations in the field. As stated before, the professional expertise should reflect the variety in networked relationships in regional economic activity: in complexity, in diversity and across scales. The heterogeneity of the groups of experts is essential to match the heterogeneity of the domain, taking the ranges and trends in transboundary competence into account.

Usually, in a consultation of the professional field, the experts are asked to translate professionalism in terms of learning outcomes (Avard & Zenios, 2012; Barrie, 2006). Asking the professional field for their demands will result in a long list of design criteria tuned to a specifically defined profession. But here, in this step of the design process, the moderators ask the professional experts to define, from the perspective of their daily core activities, the future challenges related to sustainable development in their domain. This is done in accordance with the consensus workshop method (Miller, 2007; Stanfield, 2002). In a consensus workshop approach, the broad diversity of perspectives among these experts converges in the defining of the main challenges in their domain, so building consensus. The work form of a consensus workshop of five tasks, listed in Table 3.2, guarantees an integrated description (Stanfield, 2002) of these challenges.

Table 3.2. The design process starts with the five tasks of a consensus workshop of expert professionals to get consensus on major challenges in the domain.

task	to get consensus	results in
1	Set a context	Keynote on the future of the domain by a leading expert
2	Brainstorm in layers	Brainstorm on defining the future challenges of the domain
3	Cluster ideas	Cluster these challenges
4	Name the clusters	Defining the selected clusters as new domains
5	Resolve the names	Resolve the names of these new domains

With the consensus on the major challenges to academic workers in the domain, the academic faculty acquires insight in the need for future domains and future perspectives of the world of work. These needs are the basis of what has to be learned and what this learning should involve in proficiency to handle these major challenges in sustainable development.

In a next consensus workshop, these challenges are to be diverged into manageable professional demands, fitting within the accreditation system of academic qualification. In this second workshop, the moderators ask the expert professionals to pick each of the major challenges (as defined in the first consensus workshop) to draw up job adverts for future academic personnel (Table 3.3). Job adverts are ideally suited to help professionals to organize their non-codified knowledge, as they outline the ideal candidate's qualifications and experiences (Chapman, 2001-2009). This goes in particular for the emerging field of sustainable development as it lacks structured and standardised information on qualifications in the professional domain. Part of the design process is the use of a pre-structured job advert template to outline the candidate profile, indicating desired qualifications and experiences. The job advert template (Table 3.3) is structured to the academic quality criteria, the classes of 'Dublin' Descriptors (Bergen Conference, 2005; JQI, 2004).

4.2 Application of the Design Process

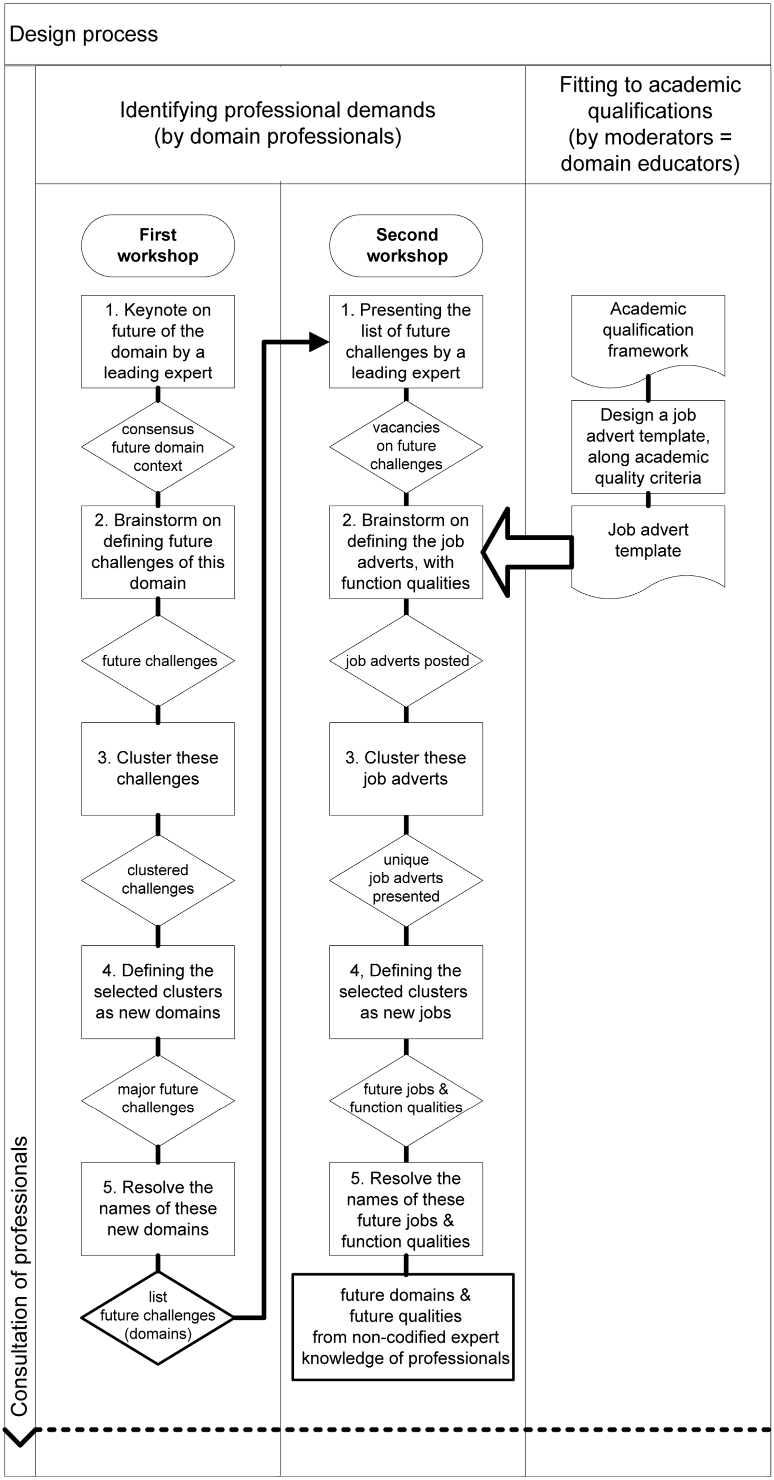
What is new in this method of consultation of the professional field is that the regional experts are triggered to concentrate on their own expertise in the professional domain challenges and define academic job qualifications and professional expertise instead of learning outcomes and graduate attributes. Moderators – university-faculty – are able to incorporate 'invisibly' the complex quality standards for academic programmes and their instructional expertise.

Table 3.3. A tool in the design process: the Job Advert template, to help professionals organize their non-codified knowledge along the academic qualification framework (here: the European Dublin Descriptors; Table 3.1).

Job advert template (searched qualifications):	Connected to Dublin Descriptor (academic qualifications standard):
The Knowledge Network Delta Water is looking for a Delta Water Scientist in the area of Delta Water Management, who is willing and able to take on the challenges of the next 10 to 20 years.	
Has knowledge of and understanding of ...	Knowledge of and understanding
Can apply knowledge and understanding in; Can carry out problem-solving tasks on ...	Applying knowledge and understanding
Can handle and make judgements on ...	Making judgements
Can communicate to enable ...	Communication
His/her learning skills enable to ...	Learning skills

This design process consists of a double round of consensus workshops (Figure 3.1), which can be done in a half-day meeting, preferably connected to a scheduled expertise exchange meeting of the professional network involved.

Figure 3.1. (next page) The design process: consultation of professionals to get consensus on domains/ challenges and on professional demands (method: two successive consensus workshops of each five tasks resulting in job adverts, structured to the qualification framework).


Design process
Identifying professional demands (by domain professionals)
Fitting to academic qualifications (by moderators = domain educators)
Consultation of professionals
First workshop
1. Keynote on future of the domain by a leading expert
consensus future domain context
2. Brainstorm on defining future challenges of this domain
future challenges
3. Cluster these challenges
clustered challenges
4. Defining the selected clusters as new domains
major future challenges
5. Resolve the names of these new domains
list future challenges (domains)
Second workshop
1. Presenting the list of future challenges by a leading expert
vacancies on future challenges
2. Brainstorm on defining the job adverts, with function qualities
job adverts posted
3. Cluster these job adverts
unique job adverts presented
4, Defining the selected clusters as new jobs
future jobs & function qualities
5. Resolve the names of these future jobs & function qualities
future domains & future qualities from non-codified expert knowledge of professionals
Academic qualification framework
Design a job advert template, along academic quality criteria
Job advert template

5 Implementation and evaluation of the design process

The design process described in section 4 was applied to the case of curriculum design for sustainable development in the domain of Water Management in the Rhine-Scheldt Delta region. During the design's implementation, opportunities for improvements were identified, both on the systematic use for curriculum design and on the specific use to identify how transboundary competence can be gained in an academic curriculum.

5.1 Identifying professional demands by consultation of professionals

Case: A New Curriculum on Delta Water Management. The consultation of professionals to identify the future challenges and related professional qualities in a changing domain, was tested in the development process of a new curriculum on Delta Water Management. As described in the introduction, in the domain of water management a strong demand for professionals exists who can operate in changing roles in interaction with academia, policy and industry. This leads to a currently renewed definition of the professional competences of the academic water manager. Government administrators, business people, and environmental educators work together in a partnership: the Knowledge Network Delta Water (KNDW). On instigation of this regional innovation network, the Zeeland University of Applied Sciences (ZU) started the development of an international graduate research degree (MSc) programme for workers in Delta water management. The Dutch-Flemish Open Universiteit (OU) developed the design process to draw-up the MSc curriculum framework, in cooperation with the institutes who intended to offer the programme: the Dutch ZU and the Belgian University of Applied Sciences West Flanders (UWF). In that phase the design process was applied and reported (Lansu, Löhr, Firssova, & Giesbertz, 2008). The aim of the design process was to design an academic curriculum for international adult education in blended learning, with enrolment of professionals in water management with a bachelor's degree (in engineering).

Participants in this survey. Participants in this professional consultation are expert professionals and the future employers of the students. Participants (N=32) were selected from the network of delta water managers (N=24) and academic faculty (N=11) in water management research. The gender distribution was 16% female and 84% male; distribution of nationality was 12.5 % Flemish (Belgian) (100% male) and 87.5% Dutch (18% female; 82% male). The estimated average age was over 40 years. The participants were asked to describe their professional function and the firm or institute they represented. We assigned these functions to categories of professional status and managerial responsibility (leadership). The majority of the participants in this survey indicated, that they had medium and upper level leadership responsibilities. About 56 % of the participants could be seen as professionals working on the highest or upper level of leadership (CEO, Dean, professor, director). The other participants (44%) had positions with medium level responsibilities (tutor, project manager, specialist). Regional distribution of participants (Figure 3.2) over the three levels of professional status shows that almost all participants at all status levels came from the Rhine-Scheldt region.

Current professional activities of these water managers (WM) were mostly (34%) on the scientific domain (universities at Zeeland, Gent and Heerlen) and in the private sector (31%). A quarter (25%) of the participants worked in public administration and about 9 % had professional activities in NGOs. To assess if the distribution of the professional sectors of our participants could be compared to others domains in SD, the data were compared with data from a survey on professional activities of environmental sciences (ES) graduates (N = 535) in Switzerland (Hansmann, Mieg, & Frischknecht, 2010).

(a)

(b)

Figure 3.2. Maps of the Rhine-Scheldt Delta with regional distribution of participants: (a) over the four professional sectors (clustered locations are Rotterdam (6 participants), Zealand (15), Ghent(3) and Heerlen (2); (b) over three levels of professional status (upper, medium, higher) [online web mapping: (BatchGeo.com, 2011; TerraMetrics, 2011)].

Notable is the larger share of the Public Sector in water management (25% on WM, 15% on ES), whereas about 50% of the participants in the environmental sciences survey work in the Private Sector (48% on ES; 2nd sector in WM with 31%) (Figure 3.3). The distribution on the sectors Science (34% on WM, 29% on ES) and NGOs (9% on WM, 7% on ES) is comparable (Figure 3.3). The larger share of public above private in water management is probably related to primary responsibility in flood control and defence by public services. Almost all sectors were distributed equally over the region (Figure 3.2) except for some experts: the moderating academics and a few employers from the private sector. With this fair regional distribution over the sectors, medium to upper level of professional status, and their many years (> 15 yr) of experience, the participants can be viewed as a representative group of leading professional experts.

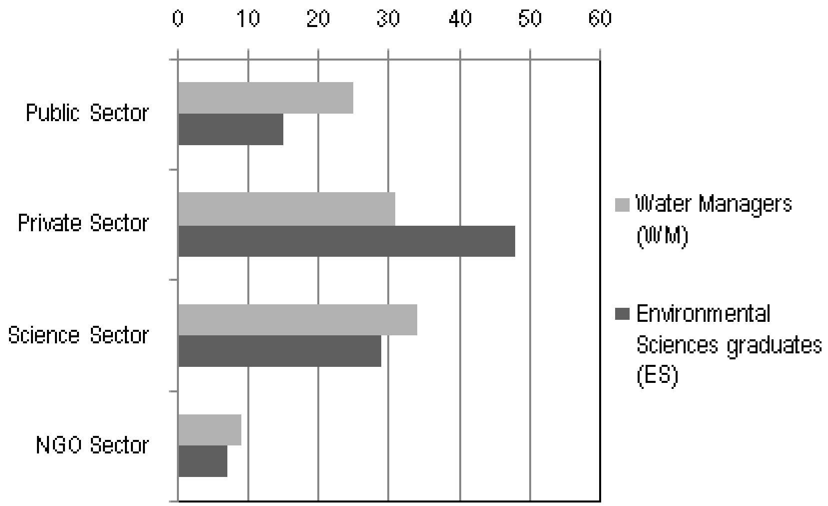


Figure 3.3. The distribution of current activities of the participants over four professional sectors; of Dutch-Flemish water management (WM) professionals (N = 32) (this survey) and of Swiss environmental sciences (ES) graduates (N=535) (Hansmann et al., 2010).

5.2 Application and evaluation of the design process

Application. The professional consultation of the water managers, was scheduled in a regular expertise exchange meeting of the delta water engineers' network (Vlissingen/Flushing, NL, January 24, 2008), applied as a double round of consensus workshops. Moderating the workshops was done by the coordinator of the network – a water manager – and two university scientists. In the consensus workshops the participants worked in five groups (5-7 persons) with mixed professional sector, each group constituted of participants from at least the three domains Private, Science, and Public. The three professionals from NGOs participated each in a different group. In the first round consensus workshop, the professionals got the task to define "Which are the challenges in delta water management in the next 10-20 years?" In a lively brainstorm, the professionals came up with 50 challenges, which were clustered to 13, from which after short presentations 7 major future challenges were selected. This consensus process results in a list of future challenges with accompanying job titles (Table 3.4).

Table 3.4. Results from the 1st round consultation on Water Management: the joint list of future challenges and the accompanying job.

Future challenge in Delta Water management	Job Title Delta Water Scientist
Integral approach (life cycles; multiple level) to water systems	Estuarine Ecosystem Scientist
Building with Nature (economy & ecology)	Wetland Engineer, Water Nature Engineer
Political administrative break-through towards non-complex water management	Political-Administrative Water Manager
Drinking Water provision (quantity & quality) by drifting fresh/salt water boundary (Ghyben-Herzberg lens)	Drinking Water Technologist
Safety, risk management & crisis management planning for future disasters	Disaster & Crisis Management Planner
Sustainable water use (greywater)	Water Technologist

In the second round workshop, the same steps were made to solve another real-task (Figure 3.1): "Draw up a job advert for a new delta water scientist to achieve this challenge in the next 10-20 years". Each workgroup, working on one or two of the challenges, outlined the ideal candidate's qualifications and experiences for this challenge. We provided a job advert template, pre-structured according academic quality standards (Table 3.3). After clustering, presenting and renaming six unique job adverts were selected, describing the professional qualifications for future delta water scientist, according to the quality standards. Figure 3.4 shows two, out of 6 results, all professional qualifications collected by these job adverts are described in Lansu et al. (2008).

In the design process of the new curriculum, the results of the professional consultation were considered as an input. The output of the first workshop, the denomination of future challenges, was used to define the domains and subjects to be learned and assessed in the study programme. The output of the second round, the job adverts, were used to define the professional competences of a delta water scientist (Table 3.5): the competence to be able to explore and to investigate in a participative manner innovative solutions for the future challenges in water management and, to be able to 'make it happen': to head for a set goal in cooperation with public and private stakeholders (Lansu et al., 2008).

Table 3.5. A result of the design process: the transboundary competence goal of future delta water scientists (Lansu et al., 2008).

The competent delta water scientist (professional with 5 years experience):
explores new and complex ideas and developments beyond discipline and culture, based on critical system analysis, on their merits for the water management challenges.
has sufficient knowledge of current technology, management processes, and multidisciplinary and participative methods to research problems in water management practice.
able to head for a set goal, by ensuring the creation of values and innovation through participatory collaboration, and can boost that the solutions are supported by the public and private parties.

The results of the design process were applied in the development phase of the new curriculum for Delta Water Management, under coordination of the engineering department of the ZU, who administers and confers the master research degree.

JOBSEARCH **DELTA WATER SCIENTIST** **Estuarine Ecosystem Scientist**	JOBSEARCH **DELTA WATER SCIENTIST** **Disaster & Crisis Planning Expert**
The Knowledge Network Delta Water is looking for a Delta Water Scientist in the area of Delta Water Management, who is willing and able to take on the challenges of the next 10 to 20 years.	The Knowledge Network Delta Water is looking for a Delta Water Scientist in the area of Delta Water Management, who is willing and able to take on the challenges of the next 10 to 20 years.
Has a good knowledge and understanding of	**Has a good knowledge and understanding of**
• coherent thinking on system levels: international/national, spatio-temporal, water/land, fresh/salt • disciplinary basis and multidisciplinary enhancement in water sciences	• Delta Water systems & flood disasters worldwide • hydraulic engineering works, water defence technologies and flood predictions
Can apply knowledge and understanding in Can carry out problem solving tasks on:	**Can apply knowledge and understanding in Can carry out problem solving tasks on:**
• thinker and actor in multidisciplinary projects • creates new ideas and outlook studies	• detailed risk scenarios and impact studies • using risk evaluations to redesign planning interventions and logistic processes
Can handle and make judgements on	**Can handle and make judgements on**
• solutions for a sustainable development • value proposition in the public debate	• local, unexpected situations by lack of data • correct customized approaches to relevant groups at risk
Can communicate to enable	**Can communicate to enable**
• defines actors in the debate and get them together • presents clearly in Dutch-English-Chinese	• in advance communication with policy and public on safety actions • participation of industry (insurance, agribusiness), policy and public
His/her Learning skills enable to	**His/her Learning skills enable to**
• analytical thinking • out-of-the-box thinking	• ongoing evaluation of new phenomena and experiences • adapting risk models and procedures
JOBADVERT CATEGORY: **Technical & Academic Research, Consultancy**	JOBADVERT CATEGORY: **Government, Consultancy**

Figure 3.4. Results from the 2nd round consultation on Water Management: two job adverts structured to the academic qualification framework.

Evaluation. The design process - the consultation of professionals – worked well and easy, it took 5 hours only. It resulted in the definition of the professional competences and the new domains in water management, according to the structure of academic quality standards.

The professionals can define – with help of university moderators and scaffold by the design methodology – the professional competences for future performance in changed roles in interaction between academia, policy, and industry. This leads to a renewed definition of the professional competences of the academic water manager, defined within the regional triple helix. The future challenges defined, match with the challenges mentioned in the Water report and assessment programme of UNESCO (2009). The German Foundation for International Business Administration Accreditation (FIBAA), a HE quality assurance organisation, evaluated the design process to define the new Master curriculum on professional qualifications as good.

The impact of this design process, interacting with the practice of regional sustainability innovations, on the curriculum seems to be significant. The joint partners within the knowledge network, are involved in joint thesis research programmes and in the development of course contents. As a result of the process, the joint partners developed four online serious games as open educational resources (emergo.ou.nl). These games are on authentic sustainability innovations in the Rhine-Scheldt Delta region, (on managed retreat of coastal levees by salt marsh ecosystems, sustainable aquaculture, local water governance on salt water intrusion, and decision-making on building with nature in sea defence): similar challenges and domains that resulted from the consultation (Table 3.4 and Figure 2.4). In this way the dynamic of professional practise is embedded into academic learning environments. Learners, in their role of delta water scientist, are confronted in the game assignments with the real regional experts, video interviewed on these issues. The learners acquire transboundary competence on water management, when they learn to handle these complex, workplace-based problems with multiple perspectives (Hummel et al., 2011). Several key elements of transboundary competence - the boundaries and approaches to cross these boundaries (Lansu et al., 2010), section 1) - can be identified in the professional competence goal of the delta water scientist (Table 3.5).

6 Discussion

The design process could be used as a guided facilitation for other institutions considering development or renewal of a curriculum for sustainable regional development, but on this point we should made some critical remarks. The study was done in the context of major revision and novel design of curricula, were competence goals have to be set. For minor revisions of the curriculum goals, the method does not seem appropriate. Also, the study is biased to the quality of the network and how its geographic boundaries are perceived internally and externally. The regional innovation network in this study is internationally recognized as well functioning incubator of joint innovation projects on sustainable delta water management. Not always such an established innovation network will be at hand.

The role of academia and their curricula in regional sustainable development is not obvious, as incentives are outputs on (inter)national research within a disciplinary context, and less on regional sustainability initiatives (Zilahy, Huisingh, Melanen, Phillips, & Sheffy, 2009) and transdisciplinary knowledge transfer between academia and stakeholders in regional development (Etzkowitz & Leydesdorff, 2000). This chapter has focused on the design process of academic curricula for sustainable development, with its rapidly and continuously changing regional needs and professional demands. Core of this professional expertise is a frequent crossing of boundaries between disciplines and perspectives, which leads to what is called in this chapter transboundary competence, a transferable competence that can be applied in professional situations different from the specific situation in which it is learned. What is to be learned is how to become a reflective and lifelong learner, while at the same time being a professional in sustainable development issues. Now, in times of crisis and demographical decline, universities are looking for more attractive and practice-inspired curricula. Changes driven by transboundary competence would increase the innovative capacity of study programmes.

Can curricula designed according to this methodology be expected to contribute to regional development? The design process analysed in this chapter consults professionals from an existing regionally based innovation network, over private, public, science and NGO sectors. It shows that sustainable education is a highly attractive issue not only to keep curricula up to the global challenge, but also to the current views on the ‘third mission’ of universities, to stimulate regional economic and social development of knowledge resources (Etzkowitz, 2003). This design process of university curricula can be seen as a regional networked learning system according Clark’s (2004) entrepreneurial university, in which the transfer of knowledge between university and the economic region (here: the Dutch-Belgian innovation network on Delta Water Management) is embedded within a well-endowed, academic curriculum framework.

In current studies, we will elaborate on the design process to evaluate the development of transboundary competence and implementation at the year-level learning experiences within a regional networked curriculum. This suits with trends in higher education to give attention to integration of transdisciplinary learning goals (Michelsen & Adomβent, 2012) and summative assessment of learning outcomes and individual academic learning outcomes in cooperative work (Wijnen & van Berkel, 2010). To ensure the national and global academic nature of such university curricula, the advent of social networking and learning technologies in curricula seems to redefine the boundaries of the regional hinterland affecting ‘local’ learning trajectories towards transboundary competence. This could not only support transboundary regional learning but also contribute to regional development by making economic activities more foot-loose, connecting the local to the global.

7 Conclusion

The problem faced in this chapter was how can a university incorporate transboundary competence for sustainable development in its view on learning and curriculum development; and how can the academic quality of learning be guaranteed. Transboundary competence, the ability to communicate and collaborate across traditional boundaries between disciplines and perspectives, while working in interaction with actors/stakeholders, is a multi-competence and mirrors the nature of sustainability science.

The two-step design process for open curriculum development, which was presented in this chapter, incorporates both the professional demands of stakeholders and the academic quality standards. The design process is illustrated on a water management curriculum in the Rhine-Scheldt Delta region. In the first step, the professional experts define, in consensus workshops, the challenges for future academic water managers. In the second step, the joint professionals outline the candidate profiles to tackle these challenges. A pre-structured job advert template, structured to the academic quality criteria for higher education (European 'Dublin' Descriptors), has been used to articulate desired qualifications and experiences. These resulted into a renewed definition of the professional, transboundary competences of the academic water manager within its regional, multi-disciplinary, multi-stakeholder contexts. The moderators of the process are able to incorporate 'invisibly' the complex (national) qualification framework for university programmes, often be seen as an obstacle for open curriculum development.

Chapter 4

Transboundary competence on sustainable development:

A roadmap merging professional demands and academic standards

The present chapter focuses on how academic curricula can cope with the rapidly changing demands in regional, knowledge-based societies. How to link learning at an academic level – with its standards and values – to the continuously changing practices for sustainable development that emerge from innovative regions, is the key question addressed in this chapter. Therefore, we discuss how one may achieve, with respect to academic curricula leading to formal degrees, that students, once graduated, are capable of working successfully as experts in such diverse roles as academics, policy-makers and business decision-makers, and of reflecting on their own performance. We propose a specific design strategy, a so-called roadmap, for acquiring transboundary competence which integrates expert advice from both professionals in the field and faculty educators with the formal quality requirements for Higher Education curricula. This design strategy has been tested on full academic degree curricula (BSc and MSc) on Environmental Sciences.

Key words: sustainable development, curriculum design, professional development, environmental sciences, transboundary competence; quality assurance; academic learning

1 Introduction

1.1 Higher education and changing societal demands

Fast developments in knowledge-based societies impact significantly on the professional requirements for both novices and experts. Flexible, tried en tested methods will be needed to adapt Higher Education curricula to these changes in order to achieve student competence development. The curriculum design itself should also allow for continuous adaptation to changing professional demands. These adaptation processes have to meet the requirements of keeping pace with professional developments and of quality in Higher Education (HE). How can the consistency of academic learning in Higher Educational programmes – with their rigorous standards and values – be linked to the required flexibility for accommodating changing practices in a knowledge-based society? In this chapter, we focus on the changing demands that emerge from sustainable regional development, by studying the design strategy applied to a BSc and an MSc academic curriculum Environmental Sciences at the Open Universiteit of the Netherlands.

Academic learning for sustainable development requires the development of transboundary competence (de Kraker et al., 2007), which implies a multi-perspective and inter- and transdisciplinary way of competence development. Because of the nature of transboundary competence development, this should be a holistic rather than a fragmented approach (de Kraker et al., 2007). Wilson et al. (2011) describe transboundary competence as an ability to engage in social learning; what counts is that professionals will adapt to roles and that competences will change over time in sync with the changes in society and professional practice (Lansu, Boon, Sloep, & van Dam-Mieras, 2012; Wilson et al., 2011). Learning in the domain of sustainable development, therefore, requires flexibility and an open curriculum. How can such a demand for transboundary competence development be reconciled with the organisational and institutional frameworks on academic quality?

The above two aspects are the key questions in this chapter, which describes a design strategy using a competence roadmap as an instrument to develop a curriculum adapted to both the persistent conditions of academic quality assurance and rapidly changing professional demands. This chapter evaluates the design strategy of using such a competence roadmap instrument during the 2006-2012 accreditation period of the BSc and MSc Environmental

Sciences programmes at the Open Universiteit, the Netherlands. The competence roadmap instrument plays a major role in the continuous improvement aimed for by the quality assurance system.

In the following paragraphs we first reflect on what it means to design academic curricula for changing societal contexts, using environmental sciences professionals as an example (Section 2.1). What are the design criteria for academic learning for sustainable development (Section 2.2) and how are these brought into the academic quality framework (Section 2.3)? We subsequently reflect on academic curricula and societal contexts (Section 2.4) and the barriers for implementing learning for Sustainable Development in academic curricula (Section 2.5).

Subsequently we describe the design strategy for academic curricula. What are the requirements (Section 3.1) and how is staff involved (Section 3.2)? How can the strategy be deployed and implemented (Section 3.3)? We finally report on the experiences with the design strategy at the Open Universiteit (Section 4).

We hope that the findings of this research will, firstly, help define the main obstacles to implementing academic curricula based on transboundary competences and, secondly, shed some light on how to cope with these obstacles.

2 Designing academic curricula in changing societal demands

2.1 Changing professional demands: environmental scientists as an example

Environmental scientists are an example of changing professions in the domain of sustainability. In the eighties and nineties, these environmental experts focused on the scientific and technical aspects of sustainability issues. They studied the human impact on natural processes, and aimed at finding technical end-of-pipe solutions (Frondel, Horbach, & Rennings, 2007), such as wastewater treatment plants. Once environmental issues such as urban soil contamination or climate change mitigation were defined, the challenge emerged that actual the problem to be solved is not exactly clear (Funtowicz & Ravetz, 1993, 1990). Such complex problems cannot be solved by neither a single scientific discipline, nor by science alone, but will require an ongoing collaboration between scientists and non-scientists of both the public and private domain ('mode 2', Gibbons et al. (1994), 'post-normal science', Funtowicz and Ravetz (1993)). Evidently, scientists have to participate in defining solutions with the other actors searching for solutions: industry, policy-makers, and citizens. Thus the transitionary and transdisciplinary role of environmental experts in crossing boundaries between disciplines and systems, had to be reframed accordingly (Bäckstrand, 2003, 2006; Kates, 2010; Kates et al., 2001; Sloep, 1994; Veldkamp et al., 2009). Recent research has increased our understanding of the challenge of learning across boundaries (Akkerman, 2011; Cummings & Kiesler, 2005). In domains neither single nor singular, Akkerman (2011) argues that "explicitly identifying boundaries enables learning since it creates a collective need to take more into account some unfamiliar perspective or practice". The current essential challenge for the domains on sustainability and environmental sciences is: How to work successfully on these boundaries, in the diverse roles of academics, policy-makers and business decision-makers, while learning to reflect on the own role as an expert. Nowadays, the domain of environmental experts seems to stretch across many heterogeneous disciplines (Hansmann et al., 2010).

From a research perspective this integrative character is shown in the novel methods of transdisciplinary knowledge integration through transdisciplinary or integrated assessments and indicators (Godemann, 2008; Hinkel, 2008). The use of the DPSIR framework on driving forces, pressures, states, impacts and responses as the strategy, analysing causal relationships in environmental problems (Frederiksen & Kristensen, 2008; Kristensen, 2004), illustrates such a transdisciplinary assessment. Other methods include handling the discursive biases of environmental research, dealing with multiple attitudes and definitions of issues by stakeholders and public (Svarstad, Petersen, Rothman, Siepel, & Wätzold, 2008), the 'Technikfolgenabschätzung in der Lehre zwischen Multi-und Transdisziplinarität', (TA-Lehre; learning on technology impact assessment (Michelsen & Adomβent, 2012; Sotoudeh & Peissl, 2010), and participatory methods to explicitly identify boundaries of domains and practices (Akkerman, 2011) in sustainability science.

From the workfield perspective, the heterogeneity and integrative character of Environmental Sciences is based on a re-analysis of data (Mieg, 2009), obtained from a survey on the Swiss market of environmental expert services by De Sombre, Woschnack, Näf, and Mieg (2002). According to Mieg (2009), the establishment of professional performance criteria in these new domains, is a task of the professional domain itself. The follow-up study by Hansmann et al. (2010), provided data on the deployment of environmental experts in sustainable development (Mieg, 2009).

The examples demonstrate that the professional demands for environmental scientists change over time and space, as does the role played by professionals working on innovations for sustainability. This requires transdisciplinary collaboration by all players (Lam, Walker, & Hills, 2012; Veldkamp et al., 2009).

2.2 Academic learning for sustainable development

The major challenge of sustainable development is how to generate and organize a good quality of life while at the same time protecting the fragile System Earth. This challenge is considered to be complex, and developing adaptation strategies is complicated further by the uncertainty of the future changes in the System Earth. Graduates from academic curricula on sustainability science will, in their (future) professional life, be working on path-breaking solutions, conceived through and required by fundamentally different sets of technologies, institutions and social arrangements (Jerneck et al., 2010; Kates et al., 2001). In their review of practices in water management studies, Pahl-Wostl, Jeffrey, Isendahl, and Brugnach (2011) conclude that making change effective will most likely result from the confrontation with a crisis or catastrophe ('cognitive variation') or by communication with actors who hold different mental models ('social variation'). Future professionals, therefore, have to cope with broad cognitive and social variations on sustainability problems (Pahl-Wostl, 2002).

Cognitive variations are engendered by the complexities and uncertainties of the analysis and research on technological, environmental, economic, or societal aspects. Social variations have been retraced to dynamic transitions between the multiple stakeholders of sustainability problems within the knowledge triangle: the networked cluster of science, the private and the public domain (van Vught, 2009). In the current European Horizons and Dutch Top Sectors technology policies, the knowledge triangle is labelled as a key driver in linking research, higher education and innovation.

Therefore, learners must learn how to cope with multi-actor perspectives, diverse, innovative methods and domains, and continuously changing professional demands. This requires that learning is informed by complex, new, non-familiar situations and action through communicative engagement across knowledge boundaries (Wilson et al., 2011; Wolf, Troxler, & Hansmann, 2011). Such a shift implies that limited mono- and multidisciplinary approaches in academic curricula on sustainability must be replaced by full multi-, inter- and transdisciplinary pedagogies (Martens, Roorda, & Cörvers, 2010; Wolf et al., 2011), so that both academics and professionals are confronted with new ideas, insights and knowledge (Steiner & Posch, 2006).

A basic precondition is the ability of actors to critically reflect on and interact with other actors while questioning their own framing (Pahl-Wostl et al., 2011). This ability to engage in social learning (Wals & Corcoran, 2012; Wilson et al., 2011) can be compared to the development of transboundary competence (de Kraker et al., 2007), and the ability to maintain a multi-perspective and inter- and transdisciplinary way of professional expertise development. This transboundary competence development will, of course, have implications for the design of academic curricula on sustainable development.

2.3 Quality frameworks for academic curricula

The influence of the labour market on academic curricula in higher education used to be limited. Faculties guaranteed the insertion of their own disciplinary professionalism (Steinert et al., 2005). The prevalence of purely academic criteria for the development of curricula changed recently through the introduction of external, authoritative bodies who assess the quality of learning outcomes and the curricula of universities. Assuming that university curricula must conform to authorative regulatory schemes, such as those imposed by accreditation bodies, the professional experience of academic workers in this domain must be used to define competence development.

Eraut (2004) argued this position in a general sense. It has been observed that a great deal of informal learning takes place in or near formal education settings (Eraut, 2004), and thus 'work' is part of the curriculum with the authenticity of the job increasing the relevance of educational contents, motivation and self-directed learning; criteria which make university adult education effective (Felder et al., 2011). However, comparative tests have shown the difficulty of providing professionals with an objective reference frame of academic criteria for evaluating their competence levels (Allen & Ramaekers, 2008).

The scholarly expertise of the faculty (domain educators) should be used to extract desirable learning outcomes from professional demands. The Delphi methodology, a method aimed at gathering the input of many experts on future challenges, is quite suitable. Based on the results of a Delphi consultation amongst researchers and educators in sustainable development, Rieckmann (2011) identified key competences for sustainable development; and Wright (2007) used this methodology in the Halifax Consultation on higher education for sustainable development (HES) to elicit the opinions of a group of HES experts for achieving a consensus position on research priorities. In both studies, the consultation was carried out with experts familiar with academic-educational terminology.

Since it is not easy to confront workfield professionals with academic criteria, (Lansu et al., 2012) studied a design process to map the future demands for young academics by directing the consultation of professionals on future challenges instead of on competences. Once these challenges were merged with the structure of academic quality standards, the consultation process resulted in the definition of professional competences and new domains. In addition, the study showed that access to an established regional innovation network of leading professionals is a prerequisite for the design process of academic curricula.

If professional practises are connected to academic learning, both the structure of the reference frames on academic criteria and the quality and connection to the regional innovation network should be studied further, however, this is beyond the scope of this chapter.

Pertinent to the studying of reference frames of academic criteria is their diversity. The selected frames on applicability in the domain of environmental sciences at Bachelor and Master level, are an American, an Australian, and the European system (as applied in the Dutch-Belgian reference framework). We compared these systems with respect to their flexibility, and surveyed the systems for 'sustainability' as a standard criterion (Table 4.1).

Table 4.1 (on two pages). Quality criteria systems, to be used in assessing academic curricula (on Environmental Sciences)

Framework of academic quality	American	European (Dutch-Belgian)	Australian
Referred to	ABET criteria	Dublin descriptors	Graduate attributes
Short description	Specific quality assurance standards set by the engineering profession	General, jointly developed standards set by higher education specialists in the Bologna process (European countries)	General employability assurance beyond disciplinary content knowledge
Source	(ABET, 2012)	(ENQA, 2009; JQI, 2004); Dutch-Belgian implementation (NVAO, 2003, 2005, 2011)	National Graduate Attributes Project, Australia; (Barrie, 2004, 2006)
References curriculum design	(Felder & Brent, 2003; Shuman et al., 2005)	(Wijnen & van Berkel, 2010)	(Avard & Zenios, 2012; Desha & Hargroves, 2007)
Scale	USA & 23 countries outside USA	European countries in and outside the European union	Australia, Scotland, Namibia & other countries
Domain	computing, engineering, and engineering technology	All formal professional and research studies in higher education (Associate degree, bachelors, masters, doctorate)	All formal studies in higher education
Level/degree	Engineering qualities on AD (2y), B (4y) & M level	Three cycles at both professional and research level (bachelors, masters, doctorate)	Graduates
Educational sector	Higher education	Higher education	Higher education
Authorative body	Engineering Accreditation Commission of the ABET; American Academy of Environmental Engineers	NVAO by the governments of the Netherlands and the Belgian region of Flanders	None, Each university develops own framework within own (national; organisational) quality framework

Framework of academic quality	American	European (Dutch-Belgian)	Australian
Criteria	General criteria for B (for M on study lead); programme criteria for Environmental Engineering programmes (for M absent)	General criteria for B and M; domain	General criteria, beyond disciplinary content knowledge
Level of criteria	Prescribed disciplines of teaching courses and study load	General outcomes at B and M level; accommodate with a wide range of disciplines and profiles and with the national variations	Generic outcomes, accommodate with a wide range of disciplines and profiles and with the national variations
Sustainability indicators	General criterion Student outcome (h.): the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context Programme criterion (proposed): Design environmental engineering systems that include considerations of risk, uncertainty, sustainability, life-cycle principles, and environmental impacts	General: making judgements B):. that include reflection on relevant social, scientific or ethical issues M):. that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgements; doctorate).. can be expected to be able to promote, within academic and professional contexts, technological, social or cultural advancement in a knowledge based society.	Indicative interpretations like Research: understand economic, legal, social, cultural and environmental issues in the use of information;

The *American system of the 'ABET criteria'* for engineering curricula (Felder & Brent, 2003; Felder et al., 2011; Shuman et al., 2005) also used outside the USA, shows specific quality assurance standards set by the engineering profession. These standards are based on general and programme criteria, both prescriptive at the level of teaching disciplines and study load. Flexibility to design the curriculum is at the topic level of a disciplinary teaching course; the discipline of the courses is set ('an earth science course') for Bachelor (and lower) programmes, and is more flexible ('specialized area') at the Master level. The system has few explicit criteria on academic learning. For 2014 a programme criterion on sustainability has been proposed; the impact in a broader context of engineering solutions is already part of a general ABET criterion.

The *Australian system of 'graduate attributes'*, which is also followed in other countries/continents, focuses on the accommodation of employability assurance beyond disciplinary content knowledge (Avard & Zenios, 2012; Barrie, 2004, 2006). The framework provides ample opportunities for accommodating graduate attributes for sustainable development within different institutional and authorative systems (Byrne et al., 2010; Desha & Hargroves, 2007; Desha et al., 2009). This framework, by its nature and objectivity – it is dedicated only to general employability assurance beyond disciplinary content knowledge –, is not intended to serve quality assurance on academic learning.

The *European framework for 'Quality Assurance in the European Higher Education Area'* (ENQA, 2009) (amongst the 27 member states of the European Union) resulting from the Bologna Process (amongst 47 member states of the Council of Europe) ensures comparability of the standards and quality of higher education thus creating a single European Educational Area (Berg et al., 2005; Bergen Conference, 2005). This organisational framework to enhance quality assurance, is based on the differentiating classes of 'Dublin descriptors' (JQI, 2004), criteria indicating the final qualifications of the three cycles: the Bachelor, Master and Doctorate degree (Table 4.2). The European qualification framework focuses on learning outcomes based on professional competences (Wijnen & van Berkel, 2010), which is in line with the observed trend in university curricula. These general standards on learning outcomes in higher education, are jointly set by higher education specialists in the Bologna process (European countries). At this generic level, the 'reflection on the broader, professional context' is part of the standard criterion on *making judgements*, in all (three) cycles (Bachelor, Master, Doctorate). There is no separate criterion on sustainable development at this level, but it could be implemented at a national, institutional or lower, e.g. curriculum, level. Since the nature of the framework is generic, the flexibility to determine learning outcomes at curriculum level is high, which complicated using the framework in discussions with professionals to reach common ground on learning outcomes.

The applied Dutch-Belgian system is the bi-national implementation of this European framework, which uses the Dublin descriptors to verify that the learning outcomes (or competences) meet these generic final qualifications according to the quality standards for the Netherlands (NVAO, 2003, 2011) and the Belgian region of Flanders (NVAO, 2005).

2.4 Academic curricula and societal contexts

An academic curriculum consists of a programme of courses. The courses are embedded in a learning environment helping students to meet the set learning outcomes, and are accompanied by an assessment strategy testing whether the learning outcomes have been achieved. Litzelman and Cottingham (2007) define this programme of courses together with the assessment strategy as the formal curriculum and the learning environment as the informal curriculum. The three quality assurance systems (Table 4.1) differ in the degree of flexibility with which academic faculties may determine their formal curriculum in terms of the final qualifications of eligible candidates. Apart from institutional and national variations, the flexibility to set learning outcomes ranges from low, at the level of course design in the professional domain is quality assurance system (e.g. the American), to high, at curriculum level in the European and the Australian system, although the latter is only directed to learning outcomes beyond disciplinary content knowledge.

From the perspective of employability, learning outcomes that have been formulated in terms of competences in the professional domain - knowledge, skills, and attitudes needed to perform tasks in real life situations- are preferred. In their synthesis of the development of expertise in engineering education, Litzinger et al. (2011) indicate that curricula often are not designed to allow learners to construct professional expertise on engineering. For knowledge production, a curriculum design with the learning environment integrated in a working context, is essential (van Lakerveld, 2005). To educate a rapidly changing professional field, universities and professionals should jointly and consciously design curricula (Arlett et al., 2010). They should aim at open curricula in which the learners – to a certain extent – choose their own learning strategy within a given programme of courses, and the degree of their engagement with social learning and current actual sources. Learning in such an open curriculum can be defined as a gradual mixture of formal and informal learning (Smith, 1999, 2008), because of the need for real life interaction with authentic problems, practices and stakeholders in the domain (the transboundary competence).

2.5 Barriers on implementing sustainable development in academic curricula

With the pending end of the UN decade 'Education for Sustainable Development' (EfSD) (2005-2014), this is the moment to evaluate the activities in higher education that have been geared towards establishing sustainable development in curricula. Recent studies (Adomßent, 2011; Adomßent et al., 2007; Barth & Rieckmann, 2012; Barth & Thomas, 2012; Lidgren, Rodhe, & Huisingh, 2006; Martens et al., 2010) have reviewed the results of these initiatives in higher education. Several research projects studied the quality of Education for sustainability in higher education (Roorda & Martens, 2008). In addition, not only in the context of the decade but also with the Rio+20 Earth Summit (June 2012) in mind, (Rikers et al., 2011) and (Tilbury, 2011, 2012) studied what universities as organisations did in structuring, supporting and stimulating sustainability in higher education and which (organisational) barriers still remain (Granados et al., 2012). Recently, (Barth & Rieckmann, 2012) evaluated academic staff development for EfSD as a factor scaffolding academic curricula and university support, while others evaluated how innovative pedagogies could help learning processes for sustainable development (Barth & Michelsen, 2012; Brundiers, Wiek, & Redman, 2010; de Kraker et al., 2007; Wals & Corcoran, 2012; Wilson et al., 2011).

All these chapters focus on academic learning curricula in higher education, formal degree programmes. Although they cover a variety of topics on establishing sustainable development, the common denominator is that curricula for sustainable development in HE are dedicated to student competence development for decision-making in a future-oriented and global perspective, in connection with knowledge production in regional sustainability initiatives (Adomßent, 2011; Adomßent et al., 2007). The suggested action is through communicative engagement across knowledge boundaries beyond the academic arena. Another finding is that many promising activities in higher education have been started (Michelsen & Adomβent, 2012), however, there is still considerable research to be done before *Education for Sustainable Development* in Higher Education curricula is really established. Changes driven by transboundary competence would, indeed, increase the innovative capacity of study programmes. Curricula dedicated to the changing demands in society, require innovative sustainable ideas as well as a response from various public and private stakeholders in the region and beyond.

Often missing in these studies, however, is the institutional dimension of these curricula changes. The studies do not explain the implementation and process monitoring of these innovative curricula designs, nor do they question whether this multi-faceted complex learning can be merged with the conditions laid down in quality frameworks on academic curricula. In this respect, (Michelsen & Adomβent, 2012; Wals & Corcoran, 2012) state that, though a lot has happened, many initiatives embedding learning for sustainable development have been based on case studies, projects and programmes with external or non-recurring funding so that they could, on the whole, operate independently from the less flexible organizational and academic structures. (Barth & Michelsen, 2012; Barth, Michelsen, & Sanusi, 2011) indicate that this seriously obstructs further incorporation of such initiatives of embedding *sustainable development* into academic curricula, within the regular, accredited (and often funded) academic programmes and at all levels of the curriculum.

This barrier for the 'sustained' implementation of sustainable development in academic learning programmes fully ties in with the key question we started with: How to cope with the requirements on transboundary competence for sustainable development within the organisational and institutional frameworks on academic quality? The use of the competence roadmap instrument described in this chapter may support the process of curriculum development within the conditions of quality assurance.

3 A design strategy for academic curricula in the knowledge society

3.1 Requirements of the design strategy

The design process described is targeted at productive interaction between the different institutional systems and traditions of scholars and workfield professionals. We take the metaphor of a *roadmap*, from enrolment in an academic curriculum to graduation as a novice professional in the knowledge society, as a planning instrument of the curriculum (Firssova & Giesbertz, 2006). If consensus is reached on the final destination ('the future demands from an academic and professional perspective on young graduates'), if the boundaries are clear ('curriculum requirements and academic quality criteria') and if the intermediary stops are known ('the distinct year levels and degrees'), a roadmap could help to infer the formal curriculum as a programme of courses and their learning outcomes from the future demands, within the framework of academic quality assurance.

Applied to the demand for transboundary competence for sustainable development, such a roadmap could also be targeted to help students meet the professional demands on transboundary competence. The resulting curriculum should be adjusted to acquire transboundary competence matching the heterogeneity of the learners' expertises and learning goals, constituted on a formal and informal curriculum that is open towards cognitive variation (current authentic roles and issues) and social variation (communication and reflection from stakeholders in the knowledge triangle).

3.2 Setting the learning outcomes by faculty

The design strategy starts with gauging the input of the intended professional competences and new domains of the curriculum. These future competences and domains can be identified by means of the professional demands on sustainable development derived from a consultation process in a regional knowledge network (Lansu et al., 2012). The learning and teaching experts in the domain – the faculty – are asked to use these outcomes to infer the intended future curriculum goals and to design a curriculum in a series of consensus workshops.

The first stage in the series of workshops is a full-faculty consensus workshop. It is to result in defining the overall goal of the curriculum and answering the question which knowledge and competences do the future academic workers in these future knowledge domains need. In line with the definition of competence as ‘meeting other people’s expectations’ (Eraut, 2004), these are called the *curriculum competences*. These professional competence goals of knowledge and performance at the level of future (young) professionals is the ‘destination’ of the roadmap, with the curriculum defined as a learning trajectory leading to this aim (Firssova & Giesbertz, 2006). As competence is seen as a moving target, these curriculum competences are described in general and are not situation-specific: they can still change over time (van Merriënboer & Sweller, 2005). This meets the need for a robust integration of the different roles professionals have to play in the changing context of their work. These competence goals of the curriculum are a translation of the professional views (future challenges and pre-structured job qualifications) on qualifications for sustainable development into academic qualifications at proficiency level (Lansu et al., 2012). The future challenges defined are indications of the complexity of the problems and denote the domains involved. The job qualifications, which were pre-structured to academic criteria, lead to the kind of academic qualifications the workfield requires. Preferably, this description of the curriculum competences is evaluated by an advisory board that spans multiple perspectives: the targeted students, alumni, professional field, academic fellows and accreditation authorities.

The second stage is the integration of the professional demands at each level of the academic curriculum (Figure 4.1; nr. 8). In three separate consensus workshops, the faculty derives from professional job qualifications the academic learning outcomes at the consecutive levels of certified research degrees (MSc, BSc) and optionally the distinct year levels and first year intake level. The faculty members in these consensus workshops are grouped along these levels by their teaching experience at each level. Besides their teaching and research expertise, the faculty uses the academic quality standards at these levels to transform the curriculum competence goals into measurable goals of the expected level of competence: the *appropriate learning outcomes*.

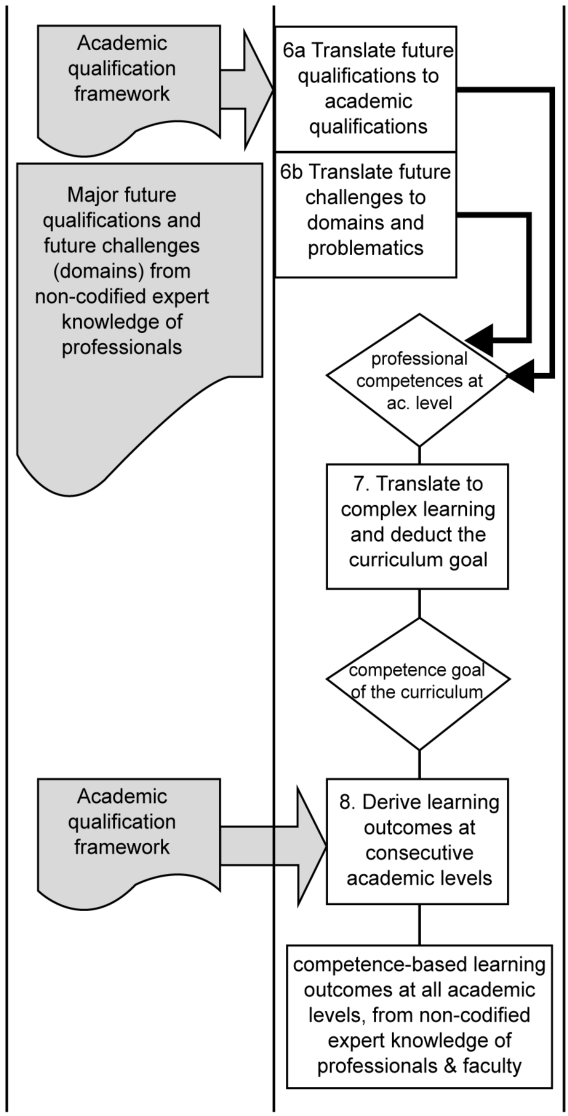


Figure 4.1. Design strategy to set the learning outcomes by the faculty
(nr. 6a; 6b are input processes of professional demands; nr. 7: the first step to set the competence goal of the curriculum;
nr. 8: the second step to define learning outcomes at the distinct levels).

The left column in Figure 4.1 on the design strategy refers to tasks executed by domain educators (experts on pedagogies in the curriculum) in the consensus workshops. The tasks executed by faculty staff (experts on learning content) are described in the right column: adjusting professional demands to academic qualifications;

with the demands identified by professionals in a earlier consultation process.

In the transformation of professional qualifications to complex learning and academic learning outcomes, the professionalism of the faculty is much needed. The faculty has the expert knowledge on how to gain proficiency in the domain. A curriculum development process integrating professionalism in the curriculum can also be a faculty development process: it may well strengthen the instructional support of students on professionalism and lead to new educational initiatives (Felder & Brent, 2003; Steinert et al., 2005).

3.3 Implementation and evaluation of the design strategy

Curriculum design. To evaluate the above design strategy, it was implemented at the School of Science of the Dutch Open Universiteit, in a Bachelor-of-Science Environmental Sciences curriculum and the corresponding Master-of-Science curriculum.

In terms of the educational organisation of these curricula, both are formal academic degree programmes offered through open and distance learning, which in principle is independent of location. Education at the Open Universiteit, offered in the Netherlands and the Belgian region of Flanders, is characterised by its form: open enrolment for anyone over 18 years (with no formal educational prerequisites for the bachelor programs); with the possibility to combine work and time, place and pace independent learning; in programmes of modular design (separate courses of 4.3 European credits with a net study load of 100-120 hours per course). The curricula are dynamic, since yearly some of its components (courses) are revised in terms of content or didactics. Open curriculum components (21.5 EC free of choice from in- and outside the university; 12.9 EC choice, from a limited list of Open Universiteit courses) can be used for personal and professional development and specialisation.

In terms of the content of these curricula, the BSc and MSc programmes in Environmental Sciences focus on sustainable development from an environmental perspective. The first year emphasizes the natural sciences, ecological health and governance perspectives. Within these environmental contexts the multiple sustainability objectives of economic vitality and socio-cultural equity are addressed besides environmental issues.

As part of the evaluation, the competence roadmap instrument that resulted from the design strategy was scrutinised for possible improvements, both with respect to the systematic use for curriculum design and to the question of how transboundary competence for sustainable development could be developed within an academic curriculum. As we were able to monitor the implementation and its effects during a single accreditation period of quality assessment (2006-2012), this process-oriented, longitudinal perspective allowed us to reflect systematically.

Quality assurance system. The authorative regulatory schemes of academic standards and values used, is the Dutch implementation of the European qualification framework (as defined by the Dutch-Belgian committee on higher education quality assurance), as already reviewed in Table 4.1 on its flexibility. As this framework, with its differentiating Dublin descriptors, focuses on learning outcomes per cycle (degree level), it has the flexibility to integrate general criteria with domain-specific professional competences. Said Dublin descriptors, described in detail in Table 4.2 (Table 3.1 idem), function as general quality criteria indicating the outcomes at successive BSc and MSc degree levels on the categories knowledge and understanding, applying knowledge and understanding, making judgements, and communication and learning skills.

Table 4.2. Quality standards for higher education: the European Dublin descriptors and their criteria at Master (2nd cycle) and Bachelor level (1st cycle) (Bergen Conference, 2005; JQI, 2004).

Dublin Descriptor	Level (= cycle)	Quality standard (differentiating Dublin Descriptor criteria between cycles)
Knowledge and understanding	Master (2nd)	Have demonstrated knowledge and understanding that is founded upon and extends and/or enhances that typically associated with the first cycle and that provides a basis or opportunity for originality in developing and/or applying ideas often in a research context.
	Bachelor (1st)	Have demonstrated knowledge and understanding in a field of study that builds upon secondary education and is typically at a level that, whilst supported by advanced text books, includes some aspects informed by knowledge at the forefront of their field of study.
Applying knowledge and understanding	Master (2nd)	Can apply their knowledge and understanding, and problem solving abilities in a new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.
	Bachelor (1st)	Can apply their knowledge and understanding in a manner that indicates a professional approach to their work or vocation, and have competences typically demonstrated through devising and sustaining arguments and solving problems within their field of study.
Making judgements	Master (2nd)	Have the ability to integrate knowledge and handle complexity, and formulate judgments with incomplete or limited information, but that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgments.
	Bachelor (1st)	Have the ability to gather and interpret relevant data (usually within their field of study) to inform judgments that include reflection on relevant social, scientific or ethical issues.
Communication	Master (2nd)	Can communicate their conclusions and the knowledge and rational underpinning these, to specialist and non-specialist audiences clearly and unambiguously.
	Bachelor (1st)	Can communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.
Learning skills	Master (2nd)	Have the learning skills to allow them to continue to study in a man self-directed or autonomous.
	Bachelor (1st)	Have developed those learning skills that are necessary for them to further study with a high degree of autonomy.

Participants. To test the design strategy, the entire academic faculty staff, examiners and tutors, of the School of Science had been involved in the application. The design strategy was composed of four consensus workshops in the academic year 2006-2007 (one workshop on the first stage; three successive workshops on the second stage). Moderators of this stage of the design strategy were faculty members and learning scientists of the Open Universiteit's

Centre of Learning Sciences and Technologies. The faculty members analysed the results of consensus workshops and drafted the redesign of the curriculum (Lansu, Ivens, & Löhr, 2006). In the second set of consensus workshops the participants, a total of 24 faculty members (38% female; 100% MSc; 71% PhD; 54% <55yr), worked in three groups (5-7 persons) at the level of their main tutoring activities (First Year, Bachelor, Master). All faculty members were involved in the process, attendance of the workshops was high, about 80 % for all meetings. Therefore, the participants may be considered as a representative group of professional experts in tutoring and assessing adult students in environmental sciences.

At the end of accreditation period of quality assessment (2012), once again the entire academic staff, a total of 27 faculty members (48% female; 100% MSc; 66% PhD; 81% <55yr) was asked to review the course programme on intended and achieved learning outcomes within the perspective of transboundary competence for sustainable development. Moderators of this review stage of the design strategy (2012-2013) were the same two faculty members who were involved in the implementation of the design strategy (2006-2007).

Learners. Both open and distance learning curricula were attended by working professionals (on average 36 years of age) from the Netherlands and Belgium (Dutch-speaking Flanders), who combine working and learning (75% works 25 hours or over). Their main motivation for choosing to study is an intrinsic interest in the domain (72%) (NW, 2013). Apart from that, a relatively large proportion of students (BSc 50%, MSc 66%) studies to improve or change their current position in the labour market (NW, 2013). These students intend to migrate to a job in the environmental/sustainability domain or to obtain a Master research degree (a condition for upper management positions in the public and science sector). Compared to students at regular universities, a significant portion of OU students have work experience (90% BSc, MSc 86%) (NW, 2013), often within the natural and technical sciences as 50% already holds a Bachelor of Engineering degree (Kastenhofer et al., 2010).

Amongst the students of the 2007-2011 period, all age groups were represented: the youngest was 18, the oldest 70 years of age (BSc 40% female, MSc 38% female), with 75-80% Dutch and 20-25 % Belgian Flemish inhabitants (Lansu et al., 2010). The largest group of students was between 20-30 years of age (BSc 67%; MSc 44%). Each year about 70 students (out of 200 starters) pass the selective entrance course year; (NW, 2013) shows that on average 42% of the students who successfully completed the entrance course, enrol in the Bachelor programme. However, there are also professionals following a course as part of a lifelong learning trajectory amongst them.

4 Case study Environmental Sciences at the Open Universiteit

4.1 Implementation of the design strategy

The first stage, a full-faculty, consensus workshop, was aimed at defining the overall goal of the curriculum: which knowledge and competences do the future, academic workers in these future knowledge domains need? Input were the domains and challenges discussed with professional experts - external members of the programme advisory board, research fellows, clients for commissioned research, faculty members, alumni and graduates - who had been asked to discuss and redefine the set goals. This first stage resulted in a renewed definition of the professional competence goal of environmental scientists (Table 4.3).

Table 4.3 A result of the design strategy: the renewed professional competence goal of environmental scientists (from Lansu et al. (2006)

The environmental scientist (professional with 5 years experience) has the ability to
describe and define a complex environmental problem using physical, social, normative, spatial and temporal features and models. (Diagnostic competence: to explore)
investigate an environmental problem from a scientific point of view, mostly in collaboration with other disciplines and/or actors, and be able to report on the matter in scientific and specialist magazines, and participate in social and scientific debates on the subject. (Research competence: to investigate)
devise, independently and tuned to the relevant actors, a sustainable solution for the environmental problem and indicate its consequences for the natural and social environment.(Intervention competence: to steer)

All faculty members participated in the first consensus workshop, aimed at transforming the professional competence goals (Table 4.3) into curriculum goals that incorporated the academic criteria at the different levels. To set these levels, the European Qualification framework with its Dublin descriptors was used (Table 4.2) in the redesign of existing accredited curricula. To explain the aim of the design strategy, the session started with a keynote on designing curricula as roadmaps to professional competency. For this, the faculty was divided into 5 working groups (of approximately 5 persons each) to brainstorm – based on the professional competences and views on the changing roles of environmental scientists in society -, on how to define a competence-defined goal for the coherent BSc and MSc study programme in Environmental Sciences. After clustering and redefining the clusters (Figure 4.1;

nr. 7) in a lively debate the faculty achieved consensus on the curriculum.

The faculty has defined the curriculum goals as the '*proficiency of the working environmental professional*': the level of someone who, after an MSc study in Environmental Sciences, has gained a few (5) years of working experience in the professional field in either the Netherlands or Flanders. This notion centres on the ability of an environmental professional to explore, describe and define complex environmental issues (*diagnosis*), to analyse from a natural sciences perspective (*research*) and to direct and advise parties on sustainable solutions for these issues (*intervention*). The development of these three areas of competence - diagnosis, research and intervention - is at the core of both programmes.

In the second stage of the design strategy, and starting from the '*proficiency of the working environmental professional'*, groups of faculty members derived the academic learning outcomes at the consecutive levels of certified research degrees (MSc, BSc) and First Year intake. In all three areas of competence, the general academic qualification criteria of the European Framework of Dublin descriptors (Bergen Conference, 2005; JQI, 2004) were used to infer learning outcomes from these competence goals (Table 4.4). Table 4.4 shows an example of this merging of professional competence with academic qualification criteria at (year) level. We describe this merging process with an example, in which the competence area is intervention, the outflow level is MSc, the academic quality criterion is the Dublin descriptor 'knowledge and understanding'. Following these requirements, the example process can be described. From the intervention competence at the professional level (The ability to devise, independently and tuned to the relevant actors, a sustainable solution for the environmental problem and indicate its consequences for the natural and social environment.), the learning outcomes at MSc level on intervention competence are inferred (The ability to devise, independently options for sustainable solutions on environmental issues, to discuss them with relevant actors and to describe them), if matched to the academic quality criterion at the MSc outflow level 'knowledge and understanding' (Have knowledge on diversity sustainable solutions on environmental issues, from current stated research).

Table 4.4. The merging of professional competence with academic qualification criteria at (year-)level: Example of intervention at the level of outflow MSc on the MSc academic criterium of knowledge and understanding

Competence area (professional level)	Qualification criteria (based on Dublin descriptors)	Competence derived (academic level)
Diagnosis ...		
Research ...		
Intervention The ability to devise, independently and tuned to the relevant actors, a sustainable solution for the environmental problem and indicate its consequences for the natural and social environment	Knowledge and understanding Have knowledge on diversity sustainable solutions on environmental issues, from current stated research	Outflow MSc The ability to devise, independently options for sustainable solutions on environmental issues, to discuss them with relevant actors and to describe them
	Applying knowledge and understanding ...	
	Making judgements ...	
	Communication ...	
	Learning ...	
		Outflow BSc ...
		First Year Intake ...

In addition to the BSc, MSc, and PhD levels described in the Dublin Descriptor's framework, the faculty felt the need to define the first-year intake level as, unlike the regular Dutch universities, the Open Universiteit – by law – has an open admission to the Bachelor programme, which means that no admission granting certificate or diploma is required. Because of this open admission, definition of the first year intake level will be helpful to both the students and tutors involved in the selective entrance course. The same methodology was used to define the first year intake level. From each of the three competence areas – diagnosis, research and intervention – the first year intake was inferred from the competence goals, and matched to the experiences of the seven first year tutors – in the absence of a Dublin Descriptor as academic intake level criterion.

The process moderators transformed the workshops results, while also integrating the European academic qualification criteria (NVAO, 2003, 2011) to a complete set of learning outcomes at three levels (MSc, BSc, First Year intake). The resulting competence roadmap (Table 4.5) (Firssova & Giesbertz, 2006) ranges from enrolment in the academic curriculum to graduation as a novice professional in the knowledge society (Lansu et al., 2006). The final destination was set (harmonised with the professional demands from the regional network of professionals) with clear boundaries (the curriculum requirements and academic quality criteria as aligned to the organisational and authorative structure of quality assurance) and obvious stops (the learning outcomes at First Year intake and BSc and MSc outflow level).

Table 4.5. A result: the competence roadmap for Environmental Sciences professionals, describing competence goals from First Year Intake through Bachelor and Master learning outcomes to a full professional.

Professional competence	(Environmental Scientists)	Diagnosis competence	Research competence	Intervention competence
Professional demands	*(result of Step 1)*	Have the ability to describe and define a complex environmental problem using physical, social, normative, spatial and temporal features and models.	Have the ability to investigate an environmental problem from a scientific point of view, mostly in collaboration with other disciplines and/or actors, and be able to report on the matter in scientific and specialist magazines, and participate in social and scientific debates on the subject.	Have the ability to devise, independently and tuned to the relevant actors, a sustainable solution for the environmental problem and indicate its consequences for the natural and social environment
Academic quality level: Master	*(based on Dublin Descriptor criteria)*	Have the ability to map an environmental problem and to define it in a scientifically well-founded manner as a probem and to determine the gravity of the problem.	Have the ability to investigate independently an environmental problem from a scientifc point of view and be able to report on the subject to a scientific audience.	Have the ability to devise independently options for sustainable solutions for environmental issues, to discuss them with relevant actors and to describe them.
Academic quality level: Bachelor	*(based on Dublin Descriptor criteria)*	Have the ability to work in a team and contribute to the mapping of an environmental problem and to further define this problem.	Have the ability to work in a team and contribute to the investigation of an environmental problem from a scientific point of view and report on the matter to the environmental professional field.	Have the ability to work in a team and contribute to the description of options for sustainable solutions for environmental issues.
Academic quality level: First Year Intake	*(deducted by faculty)*	Be conscious of the social as well as the scientific aspects of environmental problems and be able to describe this in own words.	Be willing to investigate environmental issues.	Be conscious of the diversity of options for sustainable solutions for environmental issues.

The design strategy's implementation in the Bachelor and Master curricula in Environmental Sciences resulted in a competence roadmap (Table 4.5), describing the learning outcomes at three areas of competence (diagnosis, research and intervention) at the professional level and the successive levels of academic quality.

4.2 Evaluation of the design strategy

The suitability of the competence roadmap instrument as an instrument for curriculum design was tested during the 6 year period between two successive assessments by an external committee on academic quality assurance. Assessment by such a committee is required for accreditation of the BSc and MSc study programmes (QANU, 2007). The programmes studied are the curricula of the academic years 2006-2007 and 2012-2013, as described – according to Dutch law – in the respective Education and Examination Regulations (OU, 2006, 2012).

After evaluating the instrument on its systematic use for curriculum design we identified areas for improvement.

The competence roadmap instrument (Table 4.5) was first published as part of a self-assessment by the School of Science itself on both programmes in the 2006 assessment (NW, 2006). With help of all faculty members (examiners and tutors), the process moderators listed the learning outcomes derived from the intended competence goals at the curriculum outflow levels of the curriculum matching the intended learning outcomes at the level of the modular courses.

These learning goals are conditional to the acquisition of the competence goals, as well as a further specification of the knowledge domains, insights and skills that students will acquire. For example, the *research competence goal* at BSc level is detailed in the learning outcomes 'Is familiar with the methods and techniques used in the various environmental specializations to environmental examination' and 'may, with support, contribute partially to the design (writing a research plan) and implementation of an environmental research project' (NW, 2006, 2013). The resulting roadmap with greater detail at course level (Lansu et al., 2006) was published in the 2006 assessment procedure. The intended learning outcomes described in the 2006 assessment column of Table 4.6 matched the curriculum goals at the year levels. Any open curriculum components were not included in the overview.

Table 4.6. A result of evaluation of the intended learning outcomes matched to the curriculum goals at the year levels, at the 2006 and 2012 accreditation assessment (NW, 2006, 2013).

2006 assessment	2012 assessment
In the **first year BSc** ('propedeuse'), attention is paid to the three areas of competences – diagnosis, research and intervention – mostly on diagnosis, less on research, and even less on intervention. The academic criterion of knowledge and understanding is strongly addressed.	In the **first year BSc** ('propedeuse'), attention is paid to the three areas of competences – diagnosis, research and intervention – mostly on diagnosis and research, and less on intervention. The academic criterion of knowledge and understanding is strongly addressed, but also applying knowledge and understanding, and making judgements are addressed. Less attention is paid to learning skills.
In the **second year BSc** (bachelor basics), attention is paid to the three areas of competences, mostly on research and intervention, and less on diagnosis. The academic criteria of applying knowledge and understanding, and making judgements are strongly addressed; less attention is paid to learning skills.	In the **second year BSc** (bachelor basics), attention is paid to the three areas of competences, mostly on research and diagnosis, and less on intervention. All academic criteria are strongly addressed; less attention is paid to learning skills.
In the **third year BSc** (final bachelor, incl. BSc thesis), attention is equally paid to the three areas of competences. All academic criteria (Dublin descriptors) are addressed.	In the **third year BSc** (final bachelor, incl. BSc thesis), attention is equally paid to the three areas of competences. All academic criteria (Dublin descriptors) are addressed.
In the **master year MSc** (1-yr MSc, incl. MSc thesis), attention is equally paid to the three areas of competences. Although all academic criteria (Dublin descriptors) are addressed; strong emphasis is on acquiring scientific communication skills and less attention is to making judgements, as part of the intervention competence goal.	In the **master year MSc** (1-yr MSc, incl. MSc thesis), attention is equally paid to the three areas of competences. Although all academic criteria (Dublin descriptors) are addressed; strong emphasis is on acquiring scientific communication skills and less attention is to making judgements, as part of the intervention competence goal.

The conclusion is that the roadmap instrument offers sufficient opportunities to reach '*proficiency of the environmental scientist'* and provides enough detail and tools for a continuation of the redesign of the curriculum, for example 'more emphasis in (re)newed courses on the academic criterion *making judgements*, within the competence area of intervention'. From 2007 onwards, the roadmap instrument has been integrated into the school's internal management system of educational projects. Quality criteria and stated learning outcomes must match the roadmap; amendments have to be discussed by the entire faculty.

The 2012 assessment (NW, 2013), as part of the 6-yearly academic quality assurance procedure, provides another opportunity to evaluate the competence road map instrument (described in Table 4.6; 2nd column). The process moderators made the same inventory on the basis of the renewed curriculum. The resulting overview covers the intended learning outcomes on the competence areas (Figure 4.2: D = diagnosis; R = research; I = intervention) and the content-related academic quality criteria (Figure 4.2: ku,= knowledge and understanding; ak = applying knowledge and understanding; mj = making judgements).

Firstly, we compared the results of the 2006 and the 2012 inventory, and concluded that compared to 2006, in 2012:

- the academic criterion of making judgments within the intervention competency is more explicitly addressed in both curricula (NW, 2013): modification of the curriculum.
- at the detailed level of intended learning outcomes, more courses contribute optimally to the achievement of learning outcomes at the relevant level, although some of these learning outcomes result from ‘free of choice’ courses of study activities (NW, 2013): modification of the curriculum.
- the academic criteria of ‘communication’ and ‘learning’, are no longer discussed separately for all three competence areas; they now cover all competence areas and are discussed at each level, although with stronger emphasis in later phases of the study (reflection) (NW, 2013): modification of the design strategy.

Secondly, we tested the competence roadmap for its ability to support the development of transboundary competence for sustainable development within an academic curriculum. Compared to 2006, the development of three areas of competence derived from transboundary competence, is more consistently addressed at all levels (NW, 2013): modification of the curriculum.

From the perspective of the faculty, over the past six years (accreditation period), the approach of a competence roadmap instrument has proven useful in the revision of courses along the lines of the curriculum competence goals and to further optimise the programme of courses. As a design strategy, the resulting competence road map instrument was only slightly modified: the assessment of the academic criteria on communication and learning was simplified. This process-oriented, longitudinal perspective helped the entire faculty to reflect at the level of learning outcomes (study activities) and curriculum goals.

The BSc and MSc curricula, with the applied design strategy and the resulting detailed roadmap, were reviewed by an external Dutch-Belgian accreditation committee (QANU, 2007) on behalf of the authorative body NVAO. In 2012 the roadmap was used again to assess the renewed curricula of the BSc and MSc studies in the preparation for the next accreditation assessment in 2013.

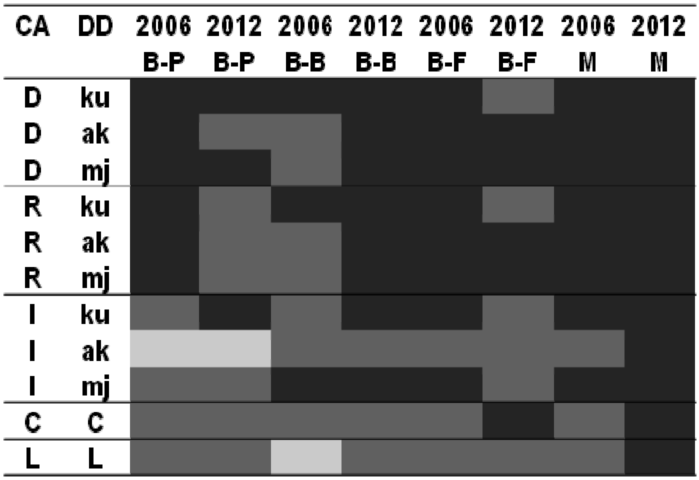


Figure 4.2. Intended learning outcomes assessed to the competence roadmap, according to competence goals (competence areas, academic quality criteria) and at the different levels of the curricula. Key:
Competence areas: D (diagnosis), R (research), I (intervention)
Academic quality criteria (Dublin descriptors): (ku= knowledge and understanding; ak = applying knowledge and understanding; mj = making judgements; C = scientific communication; L = learning skills.
Curriculum level (fase): B-P=BSc first year; B-B = BSc second year, B-F = BSc third, final year BSc; M = 1-yr MSc
Results (colours): dark = all intended learning outcomes offered at this curriculum level; medium gray = minimal one the intended learning outcome offered; light = none of the intended learning outcome offered

4.3 Reflection on the design strategy

The application of the design strategy helps to infer the formal curriculum as a programme of courses with respective learning outcomes from the future professional demands formulated within the framework of academic assurance that is the competence roadmap instrument on the BSc and MSc programmes in Environmental Sciences (Lansu et al., 2006). A study of the development of competences for sustainability by learners shows Kastenhofer et al. (2010), that the competence roadmap instrument aims at providing students with an individual experience of performing complex transboundary tasks. In addition, it allows them to develop inter- and transdisciplinary competencies for sustainable development right from the first, freshman year onwards. The 2006 accreditation review committee (QANU, 2007) was enthusiastic about the application of the roadmap instrument to designing curricula attuned to the professional demands on both the Bachelor and Master level. The committee wrote: "*The results show that these students in terms of final orientation (the environmental professional) meet the objectives.*" and "*Most alumni indicate that the study has led to an improvement of their position in the labour market.*" (QANU, 2007).

The competence roadmap instrument focused on change-oriented competence goals sketching the process of curriculum development, especially in the development of new courses, without being a blueprint. It constituted a framework for project planning of innovative initiatives, such as the collaboration in a virtual campus, and course development in cooperation with external knowledge institutions. The faculty took the idea of the transboundary competence – as elaborated in the three competence goals diagnosis, research and intervention – as guidance in curriculum and course development.

In curriculum development, the roadmap provided inspiration on what new domains could be learned in the successive years and courses. For example, the gap on the intervention goal and the climate change domain might be filled with a course devoted to lived experiences and solutions (Wilson et al., 2011).

In course development, the faculty now justifies by means of the competence roadmap course contents and pedagogies in the educational project plans that are part of the course development procedure.

Above all, the future perspectives sketched by tutors to students made starting the programme and planning the individual study programme easier as all academics, including tutors, were involved in developing and subsequently redesigning the competence roadmap.

In December 2012, the BSc programme Environmental Sciences was classified as one of the 'top' rated academic bachelor programmes 2013 in the Netherlands, the programmes with 'very good/excellent' scores in the national evaluation on learning quality (Steenkamp & Laudy, 2012). The School of Science is looking forward to the assessment by the 2013 accreditation review committee; to be expected late 2013.

5 Discussion

This chapter has focused on the design strategy of academic curricula for domains such as sustainable development, for which there are rapidly and continuously changing professional demands. The faculty used a competence roadmap instrument to design a curriculum that supported learners in achieving professional expertise performance. During the monitoring of the redesign of existing curricula, more data were at hand than in a situation merely describing the development of a new curriculum. Because of the renewal of curricula, the set of learning outcomes of former degree programmes could be used as input. In addition to that the non-codified expertise of the faculty and outputs from regular discussions with external experts, graduates and students, formally or non-formally could be incorporated in the quality assurance process.

An open curriculum, networked both in the academic and the professional practise of sustainable development, may well offer the learning opportunities to cross the boundaries between science, and the private and the public domain. In the situation of life-long learning, with professionals as students, such an open curriculum creates even more learning opportunities on ‘cognitive variation’ and ‘social variation’.

Since it was designed within the framework of both professional requirements and the (authorative) scholarly standards, the roadmap could well be of use as an instrument in academic quality assurance. In the field of education for sustainable development (EfSD) this might also help to overcome barriers in the transition from the project or case study status of EfSD initiatives to formal incorporation in full academic degree programmes.

Aspects of transboundary competence and the need for interaction outside of the academic arena can be translated to other professional domains involved in creating new knowledge, finding innovative solutions, and dealing with uncertain future challenges. Common denominators are that the individual has to keep pace with all these changes in order to function effectively in professional life (Koper, 2009; Sloep et al., 2011).

Input in the first step of the design strategy for setting curriculum goals are the professional demands (section 3.2) – resulting from consultation of the regional knowledge network on sustainable development. This orientation on the knowledge society is in keeping with the fact that a significant number of students with previous experience as (non-academic) professionals primarily aim at improving or changing their professional perspective.

Curricula at regular universities, aimed at young students with a broader, less well-defined professional perspective and region, can use defined key competencies for a Sustainable Development (Rieckmann, 2011) to set curriculum goals. Wiek, Withycombe, and Redman (2011) identified on the basis of a broad analysis of literature on higher education for sustainable development (HES) five key competencies on sustainability for academic curriculum development with identical elements as are used in the definitions of transboundary competence and the environmental competence goals diagnosis, research, intervention. Their extensive review (Wiek et al., 2011) resulted in an overview of the core concepts and methods/methodologies as well as exemplary sources of the five key competencies in sustainability. This overview would enrich the first step of the consensus workshops in the design strategy and would be helpful for creating a common ground amongst the faculty, appropriate to the actual curriculum case the design strategy is applied to, for transforming professional demands into set curriculum goals.

The design methodology was applied during the restructuring of the Bachelor (BSc, 3-yr) and Master (MSc, 1-yr) programmes in Environmental Sciences at the Open Universiteit, to meet both the societal needs and academic standards (Kastenhofer et al., 2010). At the onset of the time period studied, when the programme was fragmented into separate disciplinary subjects, ‘sustainable development’ had not been fully integrated as yet. Because of this fragmentation the learning and the assessment of learning were not in line with the need for whole-task complex learning.

6 Conclusion

This chapter focuses on how university curricula can cope with the rapidly changing demands regional knowledge-based societies make. The design strategy discussed matches learning at an academic level – with its standards and values – to the changeable practices for sustainable development that emerge from innovative regions. The design strategy – design of a competence roadmap – allows for the development of a (university-level) curriculum that is bound by both the conditions of academic quality assurance and changing professional demands.

The methodology of the design strategy aims to be a method for fine-tuning the communication between the different institutional systems and traditions of scholars and professionals. We discussed the requirements and methodology of the design strategy to integrate the rapidly changing professional demands for transboundary competence for sustainable development in the formal academic curriculum.

Chapter 5

Learning by cooperative knowledge work:

Dynamics and performances in virtual consultancy teams

This chapter reports on the design, the dynamics and the performances of learning and working in such virtual consultancy teams in a formal, academic setting: the virtual environmental consultancy (VEC) of the Open Universiteit (OUNL) in the Netherlands.

Key words: knowledge work; environmental consultancy, CSCW, working and learning, collaborative learning, performance, sustainable development

Abstract

Incorporating professional requirements into higher educational programmes is a lasting and a serious challenge. Increasingly, labour markets demand high levels of expertise, implying that also novices should be able to take up complex tasks easily. This, in turn, challenges universities to design learning environments allowing students not only to gain knowledge but also to practice the expected professionals attitudes, i.e. to become competent. The domain of sustainable development provides a particularly interesting case. Previous research on higher education for sustainable development has shown that students are expected to cooperate in multidisciplinary teams inside and outside the academic arena. The present chapter describes a learning environment designed to train the professional skills required for jobs in the domain of sustainable development. The environment allows graduate students to work as consultants in tailor-made, online teams in order to enhance their working skills and virtual mobility. Especially in the professional domain under discussion, environmental consultancy has a high degree of authenticity as it proves to be a rapidly growing profession of environmental specialists. The profession of consultant is ranked high among the growing group of knowledge workers with tasks in solving 'non-routine' problems. This chapter reports on the design, the dynamics and the performances of learning and working in such virtual consultancy teams in a formal, academic setting: the virtual environmental consultancy (VEC) of the Open Universiteit (OUNL) in the Netherlands.

1 Introduction

More and more, scientists have to be part of heterogeneous, transdisciplinary networks, in which their scientific professionalism is part of a broader process of knowledge production (Gibbons, 2003). That is why learning to work cooperatively on future challenges is one of the key competences university students should obtain during their studies. Since the 1990s, new ways of knowledge production have been discussed. An example is post-normal science (Funtowicz & Ravetz, 1990). There it is an important issue how to put a shared problem in perspective, if natural scientists are forced by stakeholders to tackle specific problems in space and time. In line with post-normal science, another way of context-driven knowledge production is Mode 2 research (Gibbons, 2003; Gibbons et al., 1994). This requires multidisciplinary teams to focus on real world problems. Gibbons' ideas derive from the insights that very often knowledge production is transdisciplinary in nature: new knowledge originates from academia in direct cooperation with stakeholders outside the academic arena. Inspired by these new ideas of knowledge production, the innovation agenda of the European Union refers to the knowledge triangle (van Vught, 2009) of education, research and innovation as the key drivers of the knowledge-based society. The necessity for cooperative work outside the academic arena is represented in the concept of the Triple Helix (Etzkowitz & Leydesdorff, 2000). This DNA metaphor of overlapping cooperation of government, industry, and knowledge institutions such as academia depicts the dynamics of innovation and the production of new knowledge. In the Triple Helix model, academia plays a key role in interacting with state and industry on regional economic development. When setting up and implementing regional sustainability plans, academics can contribute to regional sustainable development by working together with local authorities and other societal stakeholders within the Triple Helix (van Zeijl-Rozema, Cörvers, Kemp, & Martens, 2008).

As a consequence of these new insights in knowledge generation, already in their academic programmes learners at universities should be confronted with stakeholders from public sector organisations, private sector organisations and knowledge institutions. This involves learning on authentic problems in multidisciplinary teams, in contact with stakeholders from the real world, often in the form of project-based learning (Graham & Crawley, 2010; Rice, Davidson, Dannenhoffer, & Gay, 2007). In this way, learners should become sufficiently competent and innovative to face tomorrow's societal demands. However, in many fixed curricula, the constraints of time, space and pace of study impede project-based learning in cooperation with these otherwise busy stakeholders (Graham & Crawley, 2010). Didactic models, based on computer-supported cooperative work, however, could provide opportunities for the sought-after online cooperation and virtual mobility or learners. Computer-supported cooperative work is made possible by the use of groupware and social networking media, it considers in particular the spatial and temporal dimensions of work (Baecker, Grudin, Buxton, & Greenberg, 1995; Johansen, 1988). Online work allows collaboration in geo-dispersed teams, virtual teams with each team member working at his or her own location. With the aid of ICT cooperative work could be carried out at the same time (synchronously) or by each participant at her own discretion (asynchronously); this allows one to work at one's own pace. A two-dimensional matrix of space and time is often used in analysing online cooperative work.

The computer-supported cooperative work model studied in this chapter is a virtual consultancy firm which specialises in environmental and sustainability issues. This virtual environmental consultancy (VEC) has been fully described in Ivens et al. (2007) and is incorporated in the learning environment of non-traditional, adult distance education of the Open Universiteit, the Netherlands. The design and development of a virtual consultancy qua learning environment started in 1997 (Westera & Sloep, 1998; Westera et al., 2000) and, after fine-tuning and upgrading, has been running as a project-based learning environment for about 20 adult students a year, at some years in joint collaboration with faculty and students of other institutions of higher education.

The consultancy work is carried out by geo-dispersed teams of learners from the Netherlands and Belgium, who work together as consultants on research projects tasked by clients from the regional network of the university. Meanwhile, their learning is supported by a didactic model based on quality principles derived from project management (the Deming model of quality management: plan, do, check and act) and competence-based learning (de Kraker et al., 2007). Although we study a didactic model in use in an academic curriculum, the integration of learning and work need not be restricted to formal learning. In their exploratory comparative study of knowledge workers, Fruchter, Bosch-Sijtsema, and Ruohomäki (2010) found that learning and working fully integrate in knowledge workers' daily activities; they called this 'boundary science for knowledge workers'. Working in virtual space can contribute to that, as several studies show (Boer, de Gier, Verschuur, & de Wit, 2006; Fruchter et al., 2010).

The focus of this chapter then is on examining the dynamics and performances of the kind of computer-supported cooperative work (CSCW) just described. The question addressed is how well such a model suits itself to the design of learning opportunities for knowledge workers, who have to deal with continuously changing professional demands in lifelong learning. More specifically, we investigated whether the model allows learners to gain transboundary competence.

2 Virtual consultancy for sustainable development

2.1 Transboundary competence

As we hypothesised in the above, geo-dispersed cooperatively working teams of student-consultants, provide the learners the ability to obtain the skills and experiences of knowledge workers. Because the VEC is a learning environment designed to allow learners to complete their BSc thesis research work, their consultancy work should be in line with the learning outcomes expected at BSc level. In line with Eraut's definition of competence as *meeting people's expectations* (Eraut, 2004), the professional experience of academic workers in the domain should be used to define competence development. The accredited learning outcomes of the curriculum are explicitly inferred from the regionally organised formulation of professional demands in the sustainable development domain (de Kraker et al., 2007; Lansu et al., 2012). A successful strategy for coping with uncertainties and change depends on a rich diversity of perspectives (Ferrer-Balas et al., 2010; Millennium Ecosystem Assessment, 2005; van Dam-Mieras et al., 2007).

Setting up and implementing regional sustainability plans, implies a frequent crossing of boundaries between disciplines and perspectives, and ultimately leads to what is called *transboundary competence*. It is the ability to communicate and collaborate across traditional boundaries, while working in interaction with actors and stakeholders (de Kraker et al., 2007). Boundaries can be identified between the multiple perspectives one may have on sustainable development issues: between systems, disciplines, science & society, nations, cultures, and scales of space and time. The approaches to cross such boundaries should be system-oriented, interdisciplinary, transdisciplinary and participatory (Lansu et al., 2010).

2.2 Consultancy and professional demands in sustainable development

The challenge of sustainable development, or in short 'Going Green', is to generate and organise a good quality of life, while protecting the fragile System Earth. Sustainability problems are wicked and complex. They are based on data and assumptions that are plagued by uncertainty and often have a normative component as well. The new scientific field, referred to as *sustainability science* (Jerneck et al., 2010; Kates et al., 2001) bridges the natural and social sciences in an attempt to address these wicked and complex problems. Sustainability science is science, technology and innovation in support of sustainable development (Kates, 2010) and seeks practices for creative solutions to the complex issues at stake.

Consultancy work is presented in the literature, reviewed by Hislop (2002), as having a key role in stimulating innovation and ‘best practices’ in organisational practices. Consultants support clients each to construct their own meaning on their problems (Mohe & Seidl, 2011). If we look at this client-consultant relationship in a system-oriented approach, this construction of new meanings and new knowledge is done in the ‘contacts system’ between client and consultant. A consultancy work model, with the learner in the role of consultant, allows learners to become party to the production of new knowledge in interaction with the clients as societal stakeholders. In such a CSCW-model in learning, the ‘contact system’ should be designed to allow this transdisciplinary interactivity. This client-consultant relationship is influenced by the social networks and organisational cultures both client and staff are embedded in; the details of relationship will therefore influence the effectiveness of the innovation processes (Hislop, 2002). It can be argued that the social networks and organisational cultures of the client will influence learners in their role of consultant; this allows them to obtain – on top of their academic competences – professional competences and new knowledge. In regular client-consultancy relationships, consultants derive their insights in the quality of innovations and ‘best practices’ from the shape and the quality of the network relations (Hislop, 2002) they themselves maintain within their professional organisations and consultancy firms. Kitay and Wright (2003) refer to the organisational boundaries between client and consultant, and find that ‘social ties in which the formal boundaries become less distinctive’ help cross these boundaries. This fits in with the concept of the Triple Helix, which harnesses the overlapping activities between parties in regional development to realise new forms of knowledge production and innovation. Therefore in a virtual consultancy-learning environment, the student-consultants have to gauge the quality of their performance from a trinity of networks. They do so, first, from the client and the hinterland networks of the client; second, from the academic tutors with the scientific community in the background; and third - especially relevant in the case of adult learning - from their team mates and co-learners in other teams (with a diversity of formal and informal networks as being adult workers in public and private sectors).

Consultancy on environmental and sustainability issues is a rapidly growing occupation. A survey of the Swiss labour market of environmental experts services (De Sombre et al., 2002; Hansmann et al., 2010) showed a massive deployment of environmental experts in the consultancy sector since the 1990s. US Market Research (IBISWorld, 2011) shows a steady growth of 8% of the environmental consultancy sector, with positive prospects. In The Netherlands the service industry is one of the few sectors with a growing demand for higher-educated people (ROA, 2009). Therefore, a curriculum that culminates in a half year of virtual consultancy answers to professional demands. According to Mieg (2009), in these new domains - very heterogeneous in disciplines, the establishment of professional performance criteria is a task of the professional domain itself. A learner who has learned to handle these professional performance criteria will be better prepared to enter these workfield networks.

2.3 Online working and virtual mobility

The virtual consultancy-learning environment used is based on a Documentum eRoom® groupware environment (EMC Documentum eRoom, 2009). It allows students to work in tailor-made, online teams on challenging issues that are derived from the client's real-life practice.

Such virtual consultancy teams are much like regular internships in that the learning opportunities they provided help students to gain work experience at an academic level in interaction with genuine stakeholders. More importantly, virtual consultancy teams - or remote research internships (Lansu et al., 2009) - are the instrument *par excellence* for life-long learners to gain practical experience. Time and space constraints make physical internships inconvenient for these adult learners. Hence, the learning opportunities they provide help facilitate the creation of a network of contacts that will help them to jump-start their professional careers.

But in today's global and multinational business environments, collaboration in virtual teams is not merely a convenient teaching ploy, it also makes sense in its own right. More and more collaboration takes place through virtual platforms and social networks. Effective collaboration models in virtual business teams differ from onsite collaboration experiences (Dekker et al., 2008). Students, however often lack this much-needed experience with online working in teams, it just wasn't part of their education. For students to gain first-hand experience with working online, workplace learning designed like remote internships or virtual consultancies, is necessary (van Dorp et al., 2008). Based on these requirements for virtual consultancy work in learning, we describe in the next sections how networked learning and virtual work should be designed i) to meet the changing professional demands in transdisciplinary domains and ii) to foster virtual team performance in such a social network for learning.

3 Model

3.1 Consultancy as a computer-supported collaborative work (CSCW) design

As already indicated, this chapter reports on the design and the dynamics of learning and work in virtual consultancy teams in a formal, academic setting. It describes the design and development of learning in environment of virtual consultancy. The frameworks of computer-supported collaborative work (CSCW) and the Triple Helix of embedded cooperation among university, industry, and government, in new knowledge production and innovation are used as backdrops.

The dynamics of learning and work are studied in the social system with its various contact systems, both for the dynamics of the project-based consultancy work and for the dynamics of the interactions of the individual's personal development of professional competences (Figure 5.1: Organisation chart of the virtual consultancy). The dynamics of working as a consultant are analysed from the vantage point of the project team (project management; professional development) and the individual learner (competence-based personal development). The project team consists of one student who acts as project leader and two of three student who act as team members (A, in Figure 5.1). The client-consultancy relationship (2, in Figure 5.1) is the mutual relation of this team with the client, a private or public sector employer in the environmental workfield. Contact persons at the client firm or institution may be seen as mentors, who introduce the student-consultants to the data sources that are relevant to the research question. Lacking from the professional practise of consultancy and specific to the virtual learning consultancy is the relationship between the learner-consultant and the university. This relationship encompasses the dynamics of the tutor-consultancy team (3, in Figure 5.1) and the dynamics within the virtual team, that is, the peer-to-peer student relationships (1, in Figure 5.1).

The individual learners (both the team members and the project leader) are each individually coached on their personal development by a lecturer who functions as counsellor in the tutor-consultant relationship (4, in Figure 5.1). This individual tutor-consultant relationship is also available to the project leader, in spite of its absence from the organisation chart.

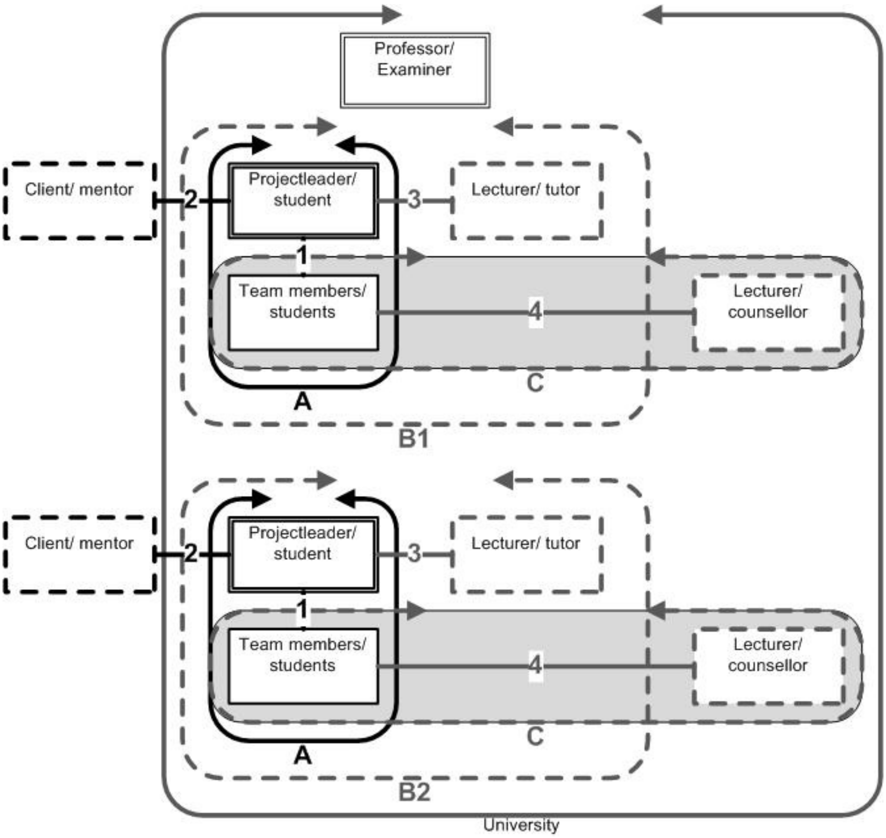


Figure 5.1. Organisation chart of the virtual environmental consultancy.

Students work in consultancy teams (space A), consisting of a student in the role of project leader and two or three students in the role of team member (student-student relationship: 1). The student consultancy team is in contact with the client (client-consultancy relationship: 2), an external stakeholder of the university outside the confines of the university. To obtain learning support to tackle the project, the student consultancy team is in contact with university lecturer (tutor-consultancy relationship: 2), meeting each other in space B. To obtain support in personal development, each student is in contact with a university counsellor (tutor-consultancy relationship: 3), meeting each other in space C. The black lines indicate 'work', the grey lines indicate 'learning'.

4 Methods to study dynamics and performances of the virtual environmental consultancy

4.1 Method

Section 4.1 describes the methods and data sources used to answer – at the course level with the virtual environmental consultancy as a model – the second research question of this dissertation:

Is it possible, with education as one of the key drivers for sustainable development, to link learning at an academic level – with its rigorous standards and values – to the dynamic practice of the professional demands of regional knowledge societies?

To answer this question we formulated six sub-questions; we have several sources of data at hand to study the dynamics and performances of learners in the virtual environmental consultancy. Here we describe these data sets. Based on the available data, we describe how we can answer questions and which methods we apply.

The first data set, the **CSVM data**, contains data about the use and the dynamics of the virtual environment; also data on demographic background, educational and professional background of participants are included. They were gathered in the context of a research and development project within the Lifelong learning programme of the European commission. This project, *cross sector virtual mobility* (CSVM), studied internship models in virtual environments. More specifically, it aimed to study the dynamic practice of professional work in a learning environment and to enhance the link between practise an theory in lifelong learning (van Dorp et al., 2008; van Dorp, Herrero de Egaña Espinosa de los Monteros, Virkus, Lansu, & Kocsis Baán, 2010). In the research project mentioned, data on the dynamics and performances of the virtual environmental consultancy (VEC) were collected (Lansu et al., 2009; Löhr & Lansu, 2008).
We will use these data in this fourth section to describe six research questions:

1. How could learners in the virtual consultancy model, as described in Section 3 work in the practise of consultancy, during the academic year? Section 4.3 describes how virtual environmental consultancy functions in practise, supported by the CSVM data on the three successive tracks started in September 2007, January 2008 and September 2009.

The second data set, the 15-years **VEC data set**, consolidates all educational and accounting information collected during the 15 years (1998-2013) the virtual environmental consultancy model ran (and still runs) at the environmental sciences bachelor (BSc) programme of the Open Universiteit. The set includes data on learning yields (grades, certification) and final products, such as research reports delivered to the clients. We will use these data on 12 successive academic years (2000/2001—2011/2012) in this fourth section to answer (in part) the research question:

2. The question *How could learners in the virtual consultancy model, as described in Section 3 be confronted with the* ***heterogeneity*** *of the practice of the professional demands in regional knowledge societies?* is tackled in Section 4.5. It describes the method we used to study this heterogeneity with the VEC data set at hand.

3. The question *How do learners learn in a virtual consultancy model, does such a model support thesis research yielding the required professional and academic* ***learning performances****?* is addressed in Section 4.6. It describes the method, based on the 15 years of VEC data, we used to study these learning performances.

4. The question *How does the virtual consultancy model, support the* ***lifelong learning*** *performance of the student consultant as future knowledge worker?* is addressed in Section 4.7. It describes the method we used to analyse the VEC dataset on this lifelong learning performance.

5. The question *How does the virtual consultancy model, support the working performances on* ***science for sustainable development****?* is tackled in Section 4.8. This question is based on the premise that a student confronted with a research question commissioned by a client targeting current, actual topics in science for sustainable development, will acquire, alone or as part of a team, the skills needed for knowledge work. To analyse the working performances in the VEC, we use the VEC data set, the official

innovation policy documents on EU Horizon (European Commission, 2011), the Dutch ‘peak sector’ (topsector) policies (Ministerie EL&I, 2011) and the report of the Royal Netherlands Academy of Arts and Sciences on Dutch strengths in *science for sustainable development* (KNAW, 2012).

6. *How does the virtual consultancy model, support the working performance demanded by the knowledge society: the practise of* ***knowledge actions by knowledge workers****?* The method to answer this question will be based on the VEC data set and the definition of knowledge actions by Reinhardt et al. (2011) and is described in Section 4.9.

4.2 Indicators

We only present data indicating the dynamics and performances of the virtual environmental consultancy (VEC) and how they affect learning, as it is impossible to measure all processes, conditions and outcomes of such a complex system. Such a complex system can only be described if we define meaningful indicators with which we try to capture its dynamics and performance, cf.(Millennium Ecosystem Assessment, 2005). An indicator is a measure that provides insight into the state of a complex system, by simplifying reality. Clearly, it only makes sense to devise indicators that focus on meaningful goals of the system. In a study on the complexity of eco-agrosystems, Piorr (2003) concluded that “It is difficult and often even impossible to characterize the functioning of a complex system, such as an eco-agrosystem, by means of direct measurements.” Piorr (2003) identified the following factors of system complexity: the size of the system, the complexity of the interactions involved, the difficulty and cost of the measurements needed. He recommends the use of a limited number of meaningful indicators. All of these factors of system complexity seem to be applicable to the VEC. The VEC course ran for 15 years, a period in which many data on multiple variables were collected and students’ products and performances were logged in the groupware system.

If we view the virtual environmental consultancy as a system, we can define some indicators to gauge the dynamics amongst the actors in the system and some indicators that measure the extent to which VEC contributes to the development of transboundary competence. The indicators we define in the next Section 4.3 are aimed to answer the questions defined in Section 4.1.

4.3 The CSVM data set

To study the dynamics and performances of the VEC as an example of computer supported collaborative work, data were collected on three successive tracks. As indicated already, this data collection was part of the European cross sector virtual mobility (CSVM) project; the three successive tracks took place in September 2007, January 2008 and September 2009 (Löhr & Lansu, 2008). A track is the period between the fixed start date of a cohort of students and the final date according to the course calendar. A track (22 weeks excluding holiday periods) starting in September will finish in the end of March; a track starting in March will end in August. Each year one or two tracks will run, with about 4 – 12 students in each track, who make up virtual teams of 3 – 4 students. Since the first pilot track, a total of 18 tracks of the virtual environmental consultancy ran.

In each case, a questionnaire was developed to collect in-depth information on dynamics among students, tutors and learners and their performances, more specifically to identify both quality and quantity of information on ICT skills, the use of ICT tools, the internship assignment, the support of the tutor and the support of the mentor. Each questionnaire was administered at the end of the track (during the final meeting with students, tutors and mentors). The results of the analysis of the data collected with these questionnaires were used to describe the VEC participants and teams.

Participants (CSVM data set). Data were collected among the 51 participants in the three tracks: 32 students (63%), 9 mentors (18%) and 10 tutors (20%), 37% of the participants were female and 63% male. About 81% of the students were certified at the end of the track (final mark 7.7 SD 0.6 on the Dutch grading scale 1-10, 10 is perfect score), 6 students dropped out from the study track in the first, planning phase of the research work, mainly because of family or work constraints. The students participated in the Sep07 track (10; 39%), in the Jan08 track (4; 15%) and in the Sep08 track (12; 46%).

Figure 5.2. Spatial distribution of the student participants and their study success.

It shows that students are fully geo-dispersed over the Netherlands and the Belgian region of Flanders. A cluster of withdrawn students can be detected in the eastern part of the Flanders region.]

In the CSVM project data set on two tracks, 40 participants were in study and 36 of them filled out the questionnaire (90% response, 71% of the track participants), 23 of them were students. The 26 students in study (100% certified; mean age = 38.2 y, SD = 9.9; of them 42% female and 58% male) are 65% of Dutch and 35% of Belgian (Flemish) nationality and all Dutch speakers (39% Dutch male; 27% Dutch female; 19% Belgian male; 15% Belgian female). In this study 3 of the 4 mentors (20% female; 80% male) filled out the questionnaire; the exact age of the mentors is unknown. All tutors in the three tracks (10) participated in the study and filled out the questionnaire (response 100%), of them 90% are Dutch and 1 (10%) is Belgian-Flemish (mean age = 47.6 y, SD = 12.4, of them 60% are female, 40% male).

Teams (CSVM data set). Although all teams started with 4 students, the 9 teams over the 3 tracks worked within teams of a mean of 2.9 students (SD 0.6) due to student withdrawal in the planning phase of the track. Table 5.1 shows the topics researched by the consultancy and commissioned by the client.

Table 5.1 An example of the research topics with the clients commissioning the research

academic year	semester start	team members (nr)	title	research project nr
20072008	sep	3	WaterQuality Biomonitor, RIVM	31
20072008	sep	4	Underground Planning, CSO	32
20072008	sep	3	Planning Sustainabilty, RCE	33
20072008	jan	2	Measuring Sustainability, OU	34
20072008	jan	2	Water Quality Industry, VIWL	35
20082009	sep	3	Energy from Northsea Seaweed Aquaculture, ECN	36
20082009	sep	3	Analysis Methods of Cocaine and Metabolites in Wastewater, Trimbos	37
20082009	sep	3	Wood transport and wood consumption for domestic heating, VITO	38
20082009	sep	3	Indoor air quality in a University Building, OU	39

Figure 5.3 is a map showing the geo-distributed nature of the teams (4 teams shown), as the students of a team study at home, distributed over the Netherlands and Belgium (mean of 240 km, SD 40).

Figure 5.3. Spatial distribution of the students participants in 4 virtual teams.

It shows that the virtual student teams are fully geo-dispersed over the Netherlands and the Belgian region of Flanders. The study location of the team members of 4 virtual teams are shown: the OUNL-EM team (research Measuring sustainability , nr 24), the OUNL-BE team (research Indoor air quality in a University Building, nr 39), the VIWL team (research Water Quality Industry, nr 35) and the Trimbos team (Analysis Methods of Cocaine and Metabolites in Wastewater, nr 37).

4.4 The VEC data set

The VEC data set, with educational and accounting information on the students working and learning in the VEC, consists of two components.

The first, major reference component is the static, general student information which is available from the student information system of the Open Universiteit; data on former studies, age, gender, pace of study, grades could be collected from this database accessible via the student's identification number. All student information collected during the time period the virtual consultancy model ran, was available, obviously under restriction of anonymity in use, at the student information system.

The second component of the VEC data set consists of all (dynamic) information resulting from the students activities in the virtual consultancy. In this study we use the data on the time schedule of activities, on the personal and project-based intermediate and final products, and the final thesis research products. All data on student enrolment, student progress and intermediate and final results, are logged at the working and learning environment of the VEC: the groupware ®EMC Documentum eRoom (2009), which allows for restricted access and archiving of logged information. In this way, each student and tutor has access to his or her own individual folder (i-dossier) to store personal information on the platform, as well as to groupfolders (project folder) of the virtual team the students works with, and conferencing folders for the team with its tutors. Parenthetically, clients who commission research assignments have no access to the eRoom platform.

4.5 Method: Heterogeneity in learning

With the multiple objectives of lifelong learning in knowledge work and the multiple perspectives of transboundary competence, learning is quite heterogeneous. This also refers to general characteristics of age, gender, and nationality (Collis & Moonen, 2001; Collis et al., 1997; van der Klink, Janssen, Boon, & Rutjens, 2011). But the indicator of heterogeneity of help in transboundary competence acquisition is heterogeneity in learning. A characteristic of learning for knowledge work, such as learning in networks, is that there are multiple objectives (van der Klink et al., 2011). This is in line with the notion of transboundary competence. Effective collaboration models in virtual business teams differ from onsite collaboration experiences (Dekker et al., 2008). Study on critical interaction behaviours among collaborating people in global virtual teams taught us that special attention is needed for cultural differences, even across Flemish and Dutch national cultures (Dekker et al., 2008). Also, heterogeneity of professional background matters. Mieg (2009) indicated that in non-consolidated professional areas of the environmental scientists, domain expertise is important. Such expertise is related to the number of *years of professional practice*. For adult students, their job domain, the work load of their job and their network of expertise all count. Educational background is yet another area of heterogeneity which matters to the students.

In this study we describe these dimensions of heterogeneity with reference to the environmental science curricula of the Open Universiteit. At a more detailed level, we describe gender and nationality differences at each academic year of the VEC course (for academic years 2000-2001 till 2011-2012).

4.6 Method: Performances in learning

If one takes the learning performances in the VEC as an indicator of the ability to study in a lifelong learning context, a simple indicator could be the final mark obtained for the course studied. The measurement of performance in learning in collaborative models is not easy, however. In the VEC model an assessment and grading procedure has been developed which takes the multiple dimensions of the didactic model into account.

Most important is the performance concerning the development of competencies in environmental sciences. This is measured using key documents that reflect students' initial intentions with respect to the competencies they seek to develop and the realisation of their intentions. These documents are stored as part of the project management trajectory. In this way, the assessor (the tutor) keeps track of the team research work, could also give support to the team, and the team gets feedback on their activities. An individual assessment of the research topic worked on is also made, in line with academic quality assurance standards for a BSc degree. In their teams, students define their one work package. This will also be part of the final research report, which will be used by the team in the final stage to provide a sound basis to the scientific writing of the final research report to the commissioning client. Besides these aspects of team and individual grading of research work (quality of contents, work, communication), the students receive feedback and marks on aspects of personal development learning (writing an personal development plan, reflecting on intermediate and final work processes and results). These intermediate marks contribute to their final mark.

Marking system. The Dutch educational marking (or grading) system, by law, employs a scale from 1 to 10: 1 being the lowest possible and 10 the highest possible; either extreme of the scale is hardly used. At 5.5 or higher the assessment is satisfactory ('pass') and the student receives a certificate. In thesis work marks lower than 5.5 (6) are non-existent, as thesis work has to be satisfactory. People destined for lower marks will have left the educational system at an earlier stage.

4.7 Method: Lifelong learning

An indicator for success in life-long learning is the degree to which students go on from one course to another or from one degree to another. In the case of the VEC, this means following study trajectories such as obtaining a certificate VEC, a BSc degree, and further study to obtain a MSc degree or even a doctorate degree in research. To flexibly cope with the study, students only commence the VEC as fulfilment of the BSc thesis if they are about to complete the final 60 ec points of their study, that is, towards the end of their BSc studies. For a limited number of students, the VEC assignment is the final study task for BSc graduation. But other students, after they finished their BSc thesis work in the VEC course, have to study several more courses from the curriculum programme to finalize their study and obtain a BSc degree. At a study pace of 12-24 ec per year, this may take as much as 2-3 years. The numbers of students eventually obtaining a BSc degree after 6 years of study in open distance education, are low compared to programmes in non-distance higher education. The rates as reported in the review of the BSc programme over the academic years 2001-2006 (NW, 2013), fluctuated between 30% (cohort 2006) and 79% (cohort 2002) with a (weighted) average of 49%. Students in the BSc programme, with a prior background in higher education (52%), tend to do better than students (33%) without it (NW, 2013). Nevertheless, these completion rates are relatively high when compared with other BSc programmes at the Open Universiteit (30 % on the Psychology BSc programme and 13% on the Management Sciences BSc programme (NW, 2013), both programmes reviewed at the same moment in time).

In the knowledge society, lifelong learning is mandatory. '*Education permanente'* (Delors, 1994) or lifelong learning is an important prerequisite for knowledge work. The future knowledge worker will have to have sufficient learning skills for his own personal and professional development form to give (Edwards, 2011; Fruchter et al., 2010). In The Netherlands and several other countries, the public-private sector demands formal degrees at academic level. It is in this sector that professionals in the environmental sciences tend to work. From an organisational point of view, the organisational structure of formal education is still indispensable to be able to train large group of people at academic level, with certified quality assurance.

Because of this relation with scientific strengths, innovation policy on topsectors and European joint collaboration (and funding), we analyse if the research topic in the VEC (period 2000-2012) has been in line with these teams. This is an indicator for the extent to which the VEC research projects are pertinent to current research and innovation themes in society, the workfield in which these future knowledge workers will work.

4.8 Method: VEC working performances on science for sustainable development

In this Section 4.8 we try to develop an indicator for matching society-based and scientific demands on science for sustainable development consultancy research in the VEC. In their analysis of the future of Dutch science for sustainable development, the Royal Netherlands Academy of Arts and Sciences (KNAW) compared the key domains on Dutch research strengths for sustainable development with the topsectors domains of Dutch innovation policy (Ministerie EL&I, 2011) and the European 'Horizon 2020' framework with the main challenges on innovation and research (European Commission, 2011).They concluded in their report '*Beyond the horizon of Rio+20*' that the partners in joint collaboration on science for sustainable development can best be identified within the European 'Horizon 2020' framework (KNAW, 2012; Ministerie EL&I, 2011). The KNAW identified existing strengths of Dutch science crucial for sustainable development on the various disciplines, which could be integrated in the scientific themes listed in the national research agenda (KNAW, 2011). The resulting domains have been indicated as strong areas in Dutch science, related to sustainable development (Table 5.2, first column from left). In the same report, the KNAW selected those topsector programmes in Dutch innovation policy (Ministerie EL&I, 2011) which have a strong orientation on sustainable development (Table 5.2, second column).

Table 5.2 Key domains for innovation and science for sustainable development, in Dutch scientific research (KNAW, 2012), in Dutch innovation policy (top sectors) (Ministerie EL&I, 2011) and in the European Horizon 2020 framework on innovation and research (European Commission, 2011).
Note: The table shows three, separate vertical lists, in which the listed key domains have no relation) if compared horizontally.

Dutch scientific research on SD	Dutch innovation policy (top sectors) on SD	European Horizon 2020 framework on SD
earth, climate, energy and bio-environment	water	health, demographic change and well-being
health and food	energy	food security, sustainable agriculture, marine and maritime research and the bio-economy
society and resilient institutions	agrofood	secure, clean and efficient energy
	chemistry	smart, green and integrated transport
	life science and health	climate action, resource efficiency and raw materials
		inclusive, innovative and secure societies

The KNAW concluded that Dutch scientists with regard to the EU Framework Program in 'Horizon 2020' (Ministerie EL&I, 2011) and sustainable development should engage in all European horizon areas, perhaps most of all in sustainable agriculture (Table 5.2, third column) (KNAW, 2012).

4.9 Method: Matching VEC tasks to knowledge worker actions

With this method we try to develop an indicator which allows us to determine to which extent the learner-consultants deploy tasks and activities which could qualify as knowledge actions. Knowledge workers, like environmental scientists, perform complex actions in various roles, which requires the level of a higher-educated worker. Their non-routine problem solving activities demand continuous training and learning at this higher level (Reinhardt et al., 2011). In their study on the knowledge worker roles and actions, Reinhardt et al. (2011) define, based on extensive literature review, a typology of knowledge actions, performed by knowledge workers (Table 5.3).

Table 5.3 A typology of knowledge actions (from Reinhardt et al. (2011)

Knowledge action	Description
Acquisition	Means gathering of information with the goal of developing skills or project or obtaining an asset.
Analyse	Means examining or thinking about something carefully, in order to understand it.
Authoring	Means the creation of textual and medial content using software system, for example, word processing systems/ presentation software
Co-authoring	Means the collaborative creation of textual and medial content using software applications, for example, word processing systems/ presentation software.
Dissemination	Means spreading information or information objects, often work results.
Expert Search	Means the retrieval of an expert to discuss and solve a specific problem.
Feedback	Refers to the assessment of a proposition or an information object. Information organisation Is the personal or organisational management of information collection.
Information search	Means looking up information on a specific topic and in a specific form. Often we search using the folder structure of a file system or we search using an information retrieval service.
Learning	Means acquiring new knowledge, skills or understanding during the execution of work or based on formalised learning material.
Monitoring	Means keeping oneself or the organisation up-to date about selected topics, for example, based on different electronic information resources.
Networking	Refers to interacting with other people and organisations to exchange information and develop contacts.
Service search	Refers to the retrieval of specialised web services that offer specific functions, for example, a translation service.

Matching the VEC tasks - that have been described in the planning schedule of tasks on personal and professional development, which in turn have been detailed in the handbook for learners in the virtual consultancy (Ivens & Lansu, 2009) - to the typology of knowledge actions by Rheinhardt and colleagues (2011), indicates the kind of knowledge work the learners perform and the extent to which the virtual consultancy model supports the working performance demanded by the knowledge society.

5 Results

5.1 The virtual environmental consultancy

Results based on the CSVM data set. In Section 4.3 we presented a description of how the virtual consultancy functions, from the perspective of the student. That description was derived from the CSVM data set on the three successive tracks (September 2007, January 2008 and September 2009). It provides insight in how professional practise and academic learning can be combined. The description given also shows how distance learners are able to work in the practise of a consultancy, during the academic year. Figure 5.2 illustrates the spatial distribution of participants. It shows that students are fully geo-dispersed over the Netherlands and the Belgian region of Flanders. Figure 5.2 combined with Figure 5.3 on the spatial distribution of the same student participants over the 4 virtual teams, reveals that teams are really geo-dispersed. The members of a virtual team are all so widely dispersed (mean distance 240 km SD 40) that working together at the same location is not feasible on a daily to weekly basis. Remarkable in Figure 5.2, is the cluster of withdrawn students, who are located in the eastern part of the Flanders region. This regional clustering might be interesting for further spatial analysis with a geographical information system, on the larger VEC data set on student withdrawal, optionally combined with other factors of heterogeneity among students like age and gender.

Several studies are done on computer-based team work and described in reviews (Graham & Crawley, 2010; Maznevski & Chudoba, 2000; Poell, Yorks, & Marsick, 2009; Westera et al., 2000), but all with a short period of exploitation. The VEC learning environment from the Open Universiteit plays an important role in supplying professional learning opportunities to non-traditional adult students. The students work as consultants in geo-dispersed teams of 3 to 4 members on authentic issues of external clients, finalising a 300 -400 hours thesis track in the virtual environmental consultancy. As shown in Table 5.1 of the research projects and bearing in mind that the clients commission (for free) these research projects, this diversity of recognized institutional clients allows these participants the opportunity to obtain both research and professional competences, within the professional network of the environmental sciences, as part of their BSc Environmental Sciences curriculum.

Results based on the VEC data set. We now present the results of the survey of the VEC data set. These various results on topics of learning by cooperative knowledge work in virtual consultancy teams will add some more details to the above description of how professional practise and academic learning can be combined.

5.2 Results on heterogeneity in learning

In this Section 5.2, we describe the indicators of heterogeneity in learning, which will be of help in gaining transboundary competence for sustainable development. We present the results based on the VEC data set on heterogeneity on the general characteristics age, gender, nationality, and on professional and educational background.

Age. In addition to the VEC data, some indicators on age characteristics come from the latest results of a review study on the quality of the Environmental Sciences (ES) programme of the OUNL. This study gives a comprehensive view of the general educational and accounting information of the BSc programme in Environmental Sciences. This review report shows that among the students (2007-2011 period), all age groups are represented; with a mean age of 36 yr, those in their twenties are the largest group of bachelor students (67%) (NW, 2013). The youngest student in the academic bachelor programme is 18 (being a distance learner because of a international modelling career) and the oldest 70 (as a post-career study (NW, 2013). These data are in line with the age-related data based on the CSVM data. We can safely assume that, with a mean age of about 36 years, there will be a large group of students with about 10 years of professional practise. Moreover, a large group of students works in a domain related to the environmental sciences. As expertise is related to the years of professional practice, these adult students collectively carry a lot of expertise with them, for the largest part in the domains of sustainability and environmental sciences.

Gender: The VEC data show that about 40% of the students in the BSc Environmental Sciences programme (2007-2011 period) are female. If we look at the VEC course (2000-2012 period), about 38% of the students enroled in the course are female, and about 39% of the VEC course certificates are awarded to female students (Table 5.4). The total of 187 certificates awarded in the 2000-2012 period were awarded to 175 individual students: some 12 students had to participate in the VEC course twice in order to fulfil their degree programme.

Table 5.4 Number of certificates (VEC course) awarded to OU students by academic year:
Total of **number of certificates**, number and percentage of certificates awarded to **females (F)**, and number and percentage of certificates awarded to **Belgian-Flemish students (B)** (said: 22% of the certificates is awarded to Belgian-Flemish students, the other 78% is awarded to Dutch students).
Remarks on the data of academic years:
* = 2000-2004, over these years 28 students and some tutors of Maastricht university (Environmental Health Sciences) participated, data not in table.
** = 2002-2003, 8 students and some tutors of Eindhoven Fontys and 9 students and some tutors of Twente university participated in the VEC, data not in the table.
***= 2011-2012 data are incomplete, concerns the 2011 semester only.

academic year	remarks	total cert (nr)	F cert (nr)	F cert (%)	B cert (nr)	B cert (%)
2000-2001	*	8	3	38	1	13
2001-2002	*	9	2	22	1	11
2002-2003	*, **	16	7	44	2	13
2003-2004	*	22	10	45	4	18
2004-2005		22	8	36	1	5
2005-2006		20	4	20	4	20
2006-2007		22	10	45	5	23
2007-2008		16	6	38	5	31
2008-2009		13	6	46	4	31
2009-2010		15	8	53	4	27
2010-2011		16	7	44	5	31
2011-2012	***	*8*	*3*	*38*	*3*	*38*
total		187	74		39	
mean		15.6	6.2	39.1	3.3	21.6
SD		5.3	2.7	9.7	1.6	10.1

Nationality. According to the BSc programme review (NW, 2013), the 18% of incoming students in the BSc Environmental Sciences programme (2007-2011 period) live in the Dutch speaking Flanders region of Belgium. If we look at the VEC course (2000-2012 period), about 22% of the course certificates are awarded to Belgian students and the remaining 78% of course certificates to students from the Netherlands (Table 5.4).

About 3 students (2%) spoke Dutch but lived outside The Netherlands or Flanders; only one had a different nationality. What we counted was the educational and professional network they oriented themselves on. These very low numbers of students with a foreign (non-Dutch, non-Belgian) nationality is remarkable, whereas participation in (Dutch-language) bachelor programmes is expected to be much higher.

Professional and educational background. Following the presentation of the results on heterogeneity with respect to general characteristics age, gender and nationality, we now present some data on the professional and educational backgrounds of students. Collaboration and confrontation with workers with different professional expertises or with different disciplinary backgrounds is needed to gain transboundary competence, we argued in Section 1. About 50% of the students (46% of female and 60% of male students) in the curricula had already obtained a degree, mostly a professional bachelor of engineering or bachelor of applied sciences degree (NW, 2013). If we look at the data on the students enroled in the Environmental Sciences programme (2007-2011 period), 75% is employed, working in a job of 25 hours and more a week, about half of them in a job related to domains on sustainable development and environmental issues. Students that took part in the remote internship pilot (2006-2008 period) of the VEC course were working professionals in ages ranging from 25 to 50 years (mean age upon enrolment in the VEC course: 40 y), the largest group working for 32 hours and more. They study part-time to finalise their BSc in Environmental Sciences (10-32 hours weekly, during 16 weeks), mainly because they want to move jobs or switch careers (Lansu et al., 2009; Löhr & Lansu, 2008). These students indicated to spend substantial time (10 hours and more) on family care and leisure activities.

Also based on these results, we may conclude that they differ substantially in *years of professional practice* compared to students in regular higher education. With a mean age of 36-40 yr in the VEC and with their background of working professionals, a mean of 10-15 years of work experience in various jobs is common. These years of expertise development in their job domain and their network of expertise (inside and outside the domain of sustainability) could be of great value in team collaboration on solving complex authentic sustainability issues. This has not been further investigated.

5.3 Results on performances in learning

The measurement of performance in collaborative learning models is complex, due to interactions in teams and between teams; also the professional and personal development of the individual students is hard to measure quantitatively. We explore the results on performances in learning using study time in months as a measure and the final grading of the studied course.

From the VEC data set, we can calculate a gross study time: the time between the date of enrolment in the course (mostly 1st of September, of 1st of March) and the registered date of official certification. The programmed VEC net study load is 22 weeks. To be able to compare calculated data of the VEC data set with this net study time, we have take into account time lags: between official start and the actual kick-off meeting (2 weeks), between the date of final publishing of the thesis report and, after handling of assessment and certification, the official date of certification (2 weeks); finally, holiday periods have to be figured in (1-2 weeks). Doing so results in a gross study time of 27-28 weeks, which is 6 to 6.5 months. If we compare this with the calculated study time in the VEC data set this is similar to the mean VEC study time (period 2000-2012) of 6.8 month (SD 1,8). If we look at the calculated study time over the successive years, we see some remarkably lower and higher means. Remarkable lower means can be observed in the academic years 2000-2001 (3.4 SD 1.1) and 2001-2002 (4.0 SD 0). These first two years were experimental years, with shorter track periods. This was in the transition time of the Bologna process, in the transition from full academic degree programmes to BSc and MSc level programmes.

Also the SD in study time differs per academic year, a higher SD (up to 7 in 20062007) means that individual students differ greatly in the time spent on their BSc thesis work in the VEC. We may conclude that the mean study time is similar to the planned study time, but will differ strongly over de years and between individuals.

If we look at the marks, the VEC data set allows us to make complex calculations on individual and team marking, marking on personal and professional development, and marking by tutor and client (mentor). For this explorative study we look at a simple measure: the final marks of the studied course model per academic year. This final mark of the VEC course, as awarded to female and to male students, includes individual and group assessments on both professional (research) and personal development. If we look at the VEC data final marking (VEC period 2000-2012) is fairly equal among female (mean 7.7 SD 0.4) and male (mean 7.6 SD 0.3). In the Dutch grading system, the 7.6 and 7.7 indicate ‘good’ on learning performances. Also over the academic years marks are quite similar with somewhat higher SD values, indicating that the individual differences are larger (but small) than the differences over the years. There is no difference in marks between women and men. It seems that the processing time (study time) spent on thesis work is a larger differentiator on academic quality than is the individual final mark.

The percentage of certification may serve as another indicator of performance in learning. Non-certification occurs if the learner has withdrawn from the course, for any reason, or, which count for the recent academic years, if the learner has prolonged his thesis work in time (variation in study time). To avoid biased results, two outliers of 42 month and 78 month of study time (but certified) were removed from the data. The VEC data on certification shows a mean of 87% (SD 8.4); which is a satisfactory to good percentage if compared to certification percentages for regular, non-thesis courses (ranging 57-95 in 2011 (NW, 2013), with lower percentages (ranging 44-97) over the 2000-2004 period (NW, 2006). Certification among female participants (92% SD 8.5) seems to be somewhat higher than among male participants (84% SD 10.9). Remarkable is the 100% score on female certification in five academic years.

Table 5.5 Indicators on study performance (VEC course) awarded to OU students by academic year:
The **study time:** the duration in month (mo) between the official start of the course and the official date of certification. Study time in practise is expected to be some 3-5 weeks shorter (without enrolment and examination procedures); 2 outliers of 42 month and 78 month of study time are removed from the data.
the **final marking of the VEC** course (in Dutch marking system, means per academic year), including individual and group assessments on professional (research) and personal development, as awarded to **female** (F) and to **male** (M) students;
the **percentage of certificated students** after enrolment in the VEC course, as is awarded to **female** and to **male** students, and **percentage of certificated students in total** (number of certificates per number of enrolments, per academic year).
Remarks on the data of academic years: see Table 5.4

academic year	study time (mo)	study time SD	F mark-mean	F mark SD	F-cert (%)	M mark-mean	M mark SD	M-cert (%)	total cert (%)
20002001	3.4	1.1	6.7	0.6	100	7.8	1.1	100	100.0
20012002	4.0	0	8.0	0.0	100	7.0	0.6	88	90.0
20022003	7.5	2.0	7.1	0.7	100	7.7	0.7	90	94.1
20032004	6.1	2.8	7.6	0.5	91	7.5	0.7	100	95.7
20042005	9.4	2.7	7.9	0.4	100	7.4	0.5	74	80.8
20052006	6.7	1.2	7.8	1.1	83	7.1	0.6	81	81.5
20062007	8.6	3.3	8.0	0.0	91	7.8	0.6	75	81.5
20072008	6.0	7.0	7.7	0.8	75	7.8	0.7	75	75.0
20082009	5.8	3.1	7.7	0.5	100	7.9	0.7	88	92.9
20092010	7.9	2.6	8.0	0.0	88	7.8	0.4	67	76.5
20102011	8.7	2.2	8.0	0.5	89	7.5	0.7	91	90.0
20112012	7.5	1.4	na	na	na	na	na	na	na
total									
mean	6.8	2.5	7.7	0.5	92.4	7.6	0.7	84.3	87.1
SD	1.8	1.7	0.4	0.4	8.5	0.3	0.2	10.9	8.4

5.4 Results on lifelong learning

As defined in the method section (4) an indicator for success in life-long learning is the degree students to which student migrate from one course to another or from one degree to another. This means following study trajectories such as obtaining a certificate VEC a BSc degree and further study to obtain an MSc degree or even a doctorate degree in research.

We describe the collected and calculated data (1) on obtaining a certificate VEC followed by a BSc degree, and (2) after further study an MSc degree.

Before we describe the results, three remarks are in order.

First, few data are available on **degree studies outside the Open Universiteit**. Only from network information we know that several former Open Universiteit students obtained an academic master degree at other universities, and some alumni are working in a PhD trajectory (Artificial Intelligence, University of Amsterdam; Spatial Ecology, NIOO, Earth Sciences, University of Oxford; Environmental Sciences, Open Universiteit).

Second, on the **comparison of VEC certificates and obtained degree diplomas**. If we compare the numbers of VEC certificates with the BSc and MSc degree diplomas obtained we should realise that an individual student can obtain one or two VEC certificates, whereas we inventory the number of individual graduates who obtained a BSc or MSc diploma (about three student do two bachelor diplomas at the OU). About 20 students have to take part in two VEC trajectories; about 12 students have already obtained two VEC certificates. This makes the number of individuals with a VEC certificate about 175 of the 187 VEC certificates awarded.

The third remark concerns the **time lag between getting a VEC certificate and being issued a diploma** of students who recently started their study**.** As we may expect, students who obtained a VEC certificate and continued their studies to obtain a BSc and thereafter an MSc diploma, need studytime between obtaining the certificates and the successive diplomas. As the majority of students study part-time, and do have to cope with personal live events in work and family, such a VEC – BSc – MSc – (PhD) trajectory can take several years. If we look at the data (Table 5.6) on the number of BSc degree diplomas we see a diminishing number of BSc degrees from 2009-2012. This should at least partly be explained by the study time needed between VEC certification and

BSc graduation. If we look at the number of MSc degree diplomas we see this 'study time' effect somewhat stronger; with the cohort of students taking the VEC course in the academic years 2008-2012 the number of MSc degrees decreased to zero (for female and for Belgian students from 2008-2012 and for Dutch men from 2010-2012). The study time needed from VEC certification, to BSc graduation and MSc graduation, hindered students (and more/longer for female and Belgian students) to acquire their MSc diploma within these years. We left out the data (in italic) on MSc graduation percentages for 2008-2012 in the calculation of the total percentages.

With these remarks in mind, with a look at the data, we may describe the lifelong learning trajectory within the formal education of the OU as follows:

About 79% (SD 13) (female 80% SD 28; Belgian 75% SD 29) of the total VEC certificates, or with the remark on double counting in mind, 85% of the students with VEC certificates obtained a BSc diploma (about 14 BSc degree diplomas yearly; 2000-2009). About 38% (SD 29) (female 34% SD 32; Belgian 49% SD 43) of the BSc graduates, which is about 31% (SD 23) of the total VEC certificates, obtained an MSc diploma (about seven MSc degree diplomas yearly; 2000-2008).

The percentages on MSc diplomas obtained per academic year of VEC certification pointed to a long study road upon MSc graduation. It is known that in the most prevalent age groups of OU students (twenties; thirties) family and work-related live events lower study pace. The percentage of Belgian-Flemish (male?) students obtaining an MSc degree upon VEC certification is remarkably higher than the percentages of female graduates and in total. This is even more remarkable if we compare this to the low 18% of Belgian students enroling in the BSc programme. This pointed at a higher motivation to an MSc degree as main aim of study. In the longer run these percentage on female and Belgian graduates might be somewhat higher, because of the study time effect.

Table 5.6 Success of the virtual consultancy model for lifelong learning and continuity in formal education.

ac. year	tot cert (Nr)	tot BSc (nr)	tot BSc (% cert)	F-BSc (%F cert)	B-BSc (% B cert)	tot MSc (nr)	tot MSc (% BSc cert)	tot MSc (% VEC cert)	F-MSc (% V BSc cert)	B-MSc (% B BSc cert)
20002001	8	7	88	100	100	6	86	75	67	100
20012002	9	6	67	50	100	5	83	56	100	100
20022003	16	12	75	71	100	8	67	50	60	100
20032004	22	20	91	100	75	9	45	41	30	67
20042005	22	16	73	75	0	5	31	23	17	
20052006	20	17	85	100	75	6	35	30	50	67
20062007	22	19	86	100	80	8	42	36	50	50
20072008	16	15	94	100	80	6	40	38	33	50
20082009	13	12	92	100	75	2	*17*	*15*	*0*	*0*
20092010	15	10	67	50	75	1	*10*	*7*	*0*	*0*
20102011	16	8	50	14	40	0	*0*	*0*	*0*	*0*
20112012	8	6	75	100	100	0	*0*	*0*	*0*	*0*
total	187	148				56				
mean	15.6	12.3	78.5	80.1	75.0	4.7	38.0	30.8	33.9	48.5
SD	5.3	5.0	13.2	28.6	29.2	3.2	29.2	23.2	32.4	42.5

Number of certificates (VEC course) by academic year awarded to OU students getting (after VEC certification their BSc degree and/or MSc degree certificate:
Total (tot) of **number of VEC certificates**, and
Total number **of BSc degree graduates (after VEC certification)**, and percentage of BSc degrees awarded to **students with an VEC certificate**; and percentage of BSc degrees awarded to **female graduates with an VEC certificate**; and percentage of BSc degrees awarded to **Belgian-Flemish graduates with an VEC certificate** (said: 75% of the Belgian-Flemish students with an VEC certificate got the BSc degrees , the other 25% is of the Belgian-Flemish students with an VEC certificate(yet) did not got the BSc degrees
Total number of MSc degree graduates (after VEC certification), and percentage of BSc degrees awarded to **graduates with an BSc certificate**; and percentage of MSc degrees awarded to **students with an VEC certificate**; and percentage of MSc degrees awarded to **female graduates with an BSc certificate**; and percentage of MSc degrees awarded to **Belgian-Flemish graduates with an BSc certificate** (said: 67% of the Belgian-Flemish students with an BSc degree got the MSc degrees, the other 33% is of the Belgian-Flemish students with an BSc degree (yet) did not got the MSc degrees ,).
Remarks on the data of academic years: 2008-2012, the data on total percentage of MSc degree certificates are incomplete, because duration of study programme (data in italic); 2011-2012 data are incomplete, the presented data concerns the 2011 semester only.

5.5 Results on VEC working performances on science for sustainable development

As an indicator on the matching of society-based and scientific demands on science for sustainable development, we analysed if the research topics the virtual (student) teams worked on, are in line with the current innovation domains. As indicated in the method description we take the prioritising of topics made in the context of the European horizons discussion as indictors. These topics are important because of the relation with Dutch scientific strengths, Dutch innovation policy and European joint collaboration (and funding),

We made an inventory based on the list of 83 thesis (team) research reports; the research-based advisory reports issue to the client, written and published by the students of the virtual consultancy teams. On basis of the expertises of the tutors, we assigned the research subject of each report to one of the topics named in the European Horizons: health, energy, resources, inclusive society, food supply, green transport (see Table 5.2 for descriptors of these key domains for innovation and science for sustainable development). Table 5.7 shows the results of this matching exercise. We tried to categorise the subjects of all the thesis research topics over the years. Notably, the research topics on which the external clients consulted the VEC can be matched to each of the key domains (Horizons). It proved that 100% of the subjects studied in the period 2000-2012 perfectly match the selected key innovation domains. All topics are studied over the years, providing a consultancy model, which achieves the wide range of future challenges in society on research and innovation. The fact that we selected, based on the KNAW study for those themes overlapping with Dutch research strengths in science for sustainable development, could be an explanation.

In Figure 5.4, we present the data on VEC research topics matching the selected EU Horizons, per academic year. Main research topics over the years concern the challenge on resources (C-Resources in Figure 5.4), formulated as the challenge to search for solutions and processes on topics such as climate action, resource efficiency and raw materials. Cleaner production technologies and the study of the effects of materials and the fate of chemicals and other human-produced materials in the environment is part of the core contents of an environmental sciences programme. The VEC research clearly suits not only professional demands but also the educational and the professional aims.

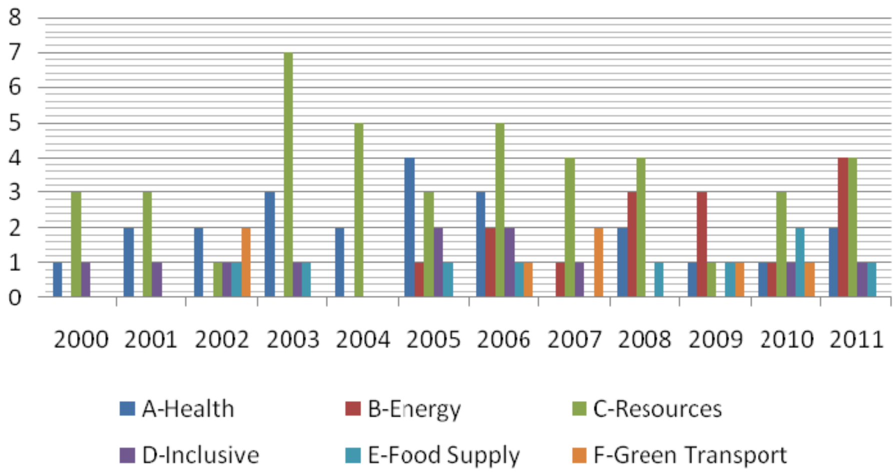


Figure 5.4. VEC research subjects on EU Horizons 2020 challenges
x-axis: academic year (2000=2000-2001
y-axis: nr of research topics scored per academic year

Some meaningful trends can be detected from the data, as shown in Figure 5.4. First, over the years less attention is paid to the domains of food supply (E in Table 5.7) and green transport (F in Table 5.7). An explanation is that agricultural life sciences and (cleaner) technologies are no major themes in the Environmental science programme, and in relation to this, less expertise is available from the external networks of tutors.

An upward trend we see in research topics on energy (B in Table 5.7; 2005 onwards). This is not only related to the strongly increasing societal awareness of sustainable energy, but also to the increasing attention to energy in the curriculum and in the faculty's network.

A downward trend can be detected to health related topics (A in Table 5.7; 2000-2006). This could be related to the waning network of the faculty in this area; the university stopped the BSc curriculum on Food & toxicology in 2003; and because the joint collaboration with Universiteit Maastricht stopped in 2005 when this university stopped its BSc programme on Environmental Health.

Table 5.7. Matching the research topics the virtual teams are working on to the challenges on the EU Horizons programme (European Commission, 2011). These challenges are related to the Dutch industrial innovation policy on top sectors

(Ministerie EL&I, 2011) and the strengths in Dutch research on science for sustainable development (KNAW, 2012)

academic year	A-Health	B-Energy	C-Resources	D-Inclusive society	E-Food Supply	F-Green Transport	total research projects
2000-2001	1	0	3	1	0	0	5
2001-2002	2	0	3	1	0	0	5
2002-2003	2	0	1	1	1	2	6
2003-2004	3	0	7	1	1	0	9
2004-2005	2	0	5	0	0	0	6
2005-2006	4	1	3	2	1	0	7
2006-2007	3	2	5	2	1	1	9
2007-2008	0	1	4	1	0	2	6
2008-2009	2	3	4	0	1	0	6
2009-2010	1	3	1	0	1	1	5
2010-2011	1	1	3	1	2	1	5
2011-2012	2	4	4	1	1	0	6
2012-2013	3	0	4	0	0	0	5
In total	26	15	47	11	9	7	80
%	32	19	59	14	11	9	

These results show the importance to work in an open, competence-based curriculum with involvement of stakeholders to meet the professional demands, in the mean time enlarging both professional competence of learners and kick-starting them into the network of the professional field. This matching exercise is a simple and efficient indicator of the extent to which the VEC research projects are pertinent to current research and innovation themes in society, the workfield in which these future knowledge workers will work.

5.6 Results on knowledge actions in the virtual environmental consultancy

To answer to the question of how the VEC model does support the knowledge actions of these future knowledge workers, the theoretical model proposed by Reinhardt et al. (2011) will be used. According to that model, we will match task activities learners perform in the virtual environmental consultancy to the list of knowledge actions.

Figure 5.5 shows the results of this matching. The numbers 1 to 30 indicate the tasks activities learners perform during their work as consultant; task #1 is an initial task at the start of their stay in the VEC, task #30 is a final task (over the 22 weeks of study time). If a task leads to the processing or creation of a product (e.g. an intermediate report; a self-reflection review), the product is listed in the second and third column: the second (vertical) column on products of team-based, professional development (e.g. task #7: write the final version of the research work plan, RWPd); the third (vertical) column on products of individual, personal development (e.g. task #3: list personal development activities to be planned; PDA). The fourth column shows which roles are involved in the activity: S= student (individual), V = virtual team/ peer students, T = tutor/academic faculty, M = mentor/client. The VEC tasks and their Dutch abbreviations are described in the planning schedule of tasks on personal and professional development, as described in the handbook for learners in the virtual consultancy (Ivens & Lansu, 2009).

The next series of columns in Figure 5.5 list each of the knowledge actions. This typology of knowledge actions derives from Reinhardt et al. (2011). It gives some indication of the kind of knowledge work the learners perform and of the extent to which the virtual consultancy model supports the working performance demanded by the knowledge society. The virtual consultancy tasks #1-30 were matched with the knowledge actions involved; e.g. the task on writing a personal development plan (PDA) is solely a student's task (S) and involves the knowledge actions of acquisition (of the one workpackage along personal motivation), information search to be able to define future research tasks and professional roles, networked with client and coaching tutor, with dissemination to the consultancy as a whole and the team on planned activities. This matching exercise results in the scheme of black (matched) boxes.

The first seven tasks we see knowledge actions typical for the onset of a research project, such as acquisition and dissemination. These tasks have a more professional character, whereas tasks such as analysing and authoring have a high level academic character.

We see an increase in complex activities over time, matching the earlier description of transboundary competence at the final half of tasks in the VEC: analysing, feedback, authoring, and learning. These complex tasks are fully trained, up to in 20 to 30 of the VEC activities. The scheme shows that future knowledge workers, exemplified by these environmental student consultants, perform complex actions in various roles, which requires the level of a higher educated worker.

With this method, we have developed an indicator, which helps to determine to which extent, during their stay the learner-consultants deploy tasks activities, which could be marked as knowledge actions.

Figure 5.5. (next page) Knowledge actions and number of knowledge actions, in order of complexity from acquisition to learning according the classification of (Reinhardt et al., 2011), matched to student's successive task activities (from 1 to 30) they perform during their study period in the virtual environmental consultancy.
Nr. = number of the successive student's task activity in VEC
Product prof. = Code of the product of professional development (research project) in VEC delivered by those mentioned in Role column. Coding from Handbook virtual environmental consultancy (Ivens & Lansu, 2009)
Product pers. = Code of the product of personal development in VEC delivered by those mentioned in Role column. Coding from Handbook virtual environmental consultancy (Ivens & Lansu, 2009).
Role = Indicated are those who collaborate with the student in fulfilling the student's successive task activity (Nr) and products form professional and personal development in VEC: student (S), virtual team (V), academic tutor (T) and/or the mentor at the client/ employer (M).
Knowledge actions (columns from Acquisition to Learning) virtual environmental consultancy by an individual student (S), in collaboration with those mentioned in column row, virtual team (V), academic tutor (T) and/or the mentor at the client/ employer (M).

nr	product prof.	product pers.	role	knowledge actions												
				Acquisition	Service search	Dissemination	Information search	Expert Search	Monitoring	Co-authoring	Information org.	Networking	Analyze	Feedback	Authoring	Learning
				5	*6*	*7*	*13*	*14*	*15*	*16*	*19*	*20*	*20*	*23*	*23*	*30*
1	HBK1	HBK2	S	1			1									1
2			SV		1		1	1			1	1				1
3	RWA	PDA	S	1		1	1					1				1
4	PS1	PS1	SVT					1			1	1				1
5	RWC		SVM	1	1		1	1				1				1
6		*PDPd*	ST	1									1		1	1
7	*RWPd*		SVTM	1			1	1		1		1	1	1	1	1
8		PDPf	ST						1				1	1	1	1
9	RWPf		SVTM				1	1	1	1		1	1	1	1	1
10			SVTM		1		1	1		1	1	1	1	1	1	1
11			SCT		1		1	1		1	1	1	1	1	1	1
12	PS2	PS2	SVCT			1			1	1	1	1		1	1	1
13			SVT											1		1
14		*PDR1d*	S						1				1	1	1	1
15		PDR1f	ST						1		1	1	1	1	1	1
16	*RWR1d*		SV				1	1	1	1	1		1	1	1	1
17	RWR1f		SVTM					1	1	1	1	1	1	1	1	1
18			SVTM		1		1	1		1	1	1	1	1	1	1
19			SCT		1		1			1	1	1	1	1	1	1
20	PS3	PS3	ST			1			1	1	1	1		1	1	1
21	*RWR2d*		SV				1	1	1	1	1	1	1	1	1	1
22	RWR2f		SVTM			1		1	1	1	1	1	1	1	1	1
23	PWLL		SVT			1			1	1	1		1	1	1	1
24	PS4	PS4	SVTM			1		1	1	1	1	1		1	1	1
25			SVT											1		1
26	RWWR		S				1				1		1		1	1
27	*PWARd*		SV							1	1	1	1	1	1	1
28	RWARf		SVTM			1		1	1	1	1	1	1	1	1	1
29		*PDR2d*	S						1				1	1	1	1
30		PDR2f	ST						1		1	1	1	1	1	1

6 Conclusion and Discussion

6.1 Conclusion

By way of conclusion, this section provides a comprehensive answer to the research questions posed Section 4. We examined the dynamics and performances of the virtual environmental consultancy, a computer-supported cooperative work (CSCW) model on BSc thesis research in the Environmental Sciences programme at the Open Universiteit. Based on the results, we try to answer the question whether the model allows learners to gain transboundary competence for sustainable development; or in a broader perspective, how well such a model suits itself to the design of learning opportunities for lifelong learning knowledge workers, who have to deal with continuously changing professional demands.

Our findings support the conclusion that, broadly speaking, a virtual consultancy model fully suits the professional demands and learning opportunities for knowledge workers. Heterogeneity in learning helps to develop transboundary competence in learners, to solve ‘non-routine’ problems. The virtual consultancy model allows for heterogeneity in age, in gender and nationality (although restricted to Dutch speaking Belgian and Dutch participants). The model also allows for heterogeneity in professional and educational background, which implies a rich environment of professional expertise and disciplinary expertise, which makes that these adult students collectively represent a wide range of expertises. These findings are in line with the results based on a detailed study to three successive tracks (CSVM data set). VEC participants study part-time, they mainly want to migrate to higher-level jobs or switch careers. Their years of professional expertise (10-15 years is common) in their job domain and their network of expertise could be of great help in team collaboration on solving complex authentic sustainability issues.

Although the measurement of performances in collaborative learning models is complex, the results of the VEC data explored support the finding that i) the mean study time is similar to the planned study time, but ii) will differ strongly over the years and between individuals, which allows for a high pace of study in open distance learning. Over the academic years learning performances are good and fairly equal among female students, with individual differences larger (but still small) than differences over the years. The percentage of certification (87%, SD 8.4) supports this finding of a good learning performance, at least in open distance learning. Good performance oin lifelong learning of former participants of the VEC model furthermore supports the idea that such a model helps to motivate learners to keep learnign during their career: VEC participants, after certification, continue studying and obtain a BSc degree (79% SD13) or even an MSc degree (38% SD 29).

100% of the thesis research subjects (2000-2012) match perfectly the key domains of research and innovation (European Horizons) in science for sustainable development. Among these thesis research subjects, the main 'Horizon' over the years is the 'Resources' domain, with an upward trend for 'Energy' and a downward trend for 'Health', in keeping with the trends in focus of the degree programmes and faculty.

VEC students are confronted, in various roles, with an increase in complex knowledge actions. These are key actions in the job tasks of knowledge workers, and so support the future environmental scientist in their role as knowledge worker on the complex sustainability issues.

6.2 Discussion

This discussion section briefly looks at the implications of our findings. Suggestions for further development and research are described in Section 7.

Knowledge transfer. Our findings in this research on the performance dynamics of the learners in the virtual environmental consultancy show how important it is to work and learn in an open curriculum, open to interact with stakeholders. We focussed on the student, as a learner-consultant who is member of a team formed by fellow learners. The heterogeneity in professional and educational background of these teammates, with their years of professional and disciplinary experience, supports them in their academic, professional, and personal development. Topics researched matched for a full 100% to the key domains in sustainable development. Because faculty are fully involved in the coaching of these learner-consultants in their thesis research, this learning environment is also an instrument or tool for faculty. It allows them to stay informed about the latest, actual research done within these key domains of innovation. From the findings, the increasing of commissioned research on energy topics and the decreasing popularity of commissioned research on health topics illustrate the connectedness of the student research projects in the VEC with the faculty's research and network. Apparently, this knowledge transfer from the client's issues via the consultancy research in the virtual student teams to the faculty in general affects the curriculum; it helps faculty keep at pace with the knowledge society in terms of contents and competences. Examples are courses on new topics, multi-media case studies, media-attention and even clients invited to lecture on current topics. The VEC data set has only been superficially researched; it allows of further research on this aspect of knowledge transfer from the perspective of the client and faculty,

Academic and professional quality of thesis work. The findings show, almost uniformly over the academic years, 'good' performances on learning, with high marks fairly equally spread over female (mean 7.7 SD 0.4) and male (7.6 SD 0.3) students. It seems that the time spent on thesis work is a larger differentiator for academic quality than the individual, final marking; although students are marked individually for their thesis work, the marks reflect the result of a learning process trough contacts with other students, with tutors and professionals in the field. That means that traditional ways of marking do not reflect adequately the effects of regular feedback and learning in a network. The findings of this research were based on the final marks. Because of the complexity of learning in a cooperative work environment, the final mark is based on partial marking and structured list of feedback topics. The VEC data set allows us to make complex calculations and evaluations of these marks and feedback information. In further research the VEC data set can be questioned in more detail on academic and professional quality of the thesis work. It contains data on individual and team marking, on personal and professional development, on marking by faculty (on academic quality) and by the client (who as mentor in the 'research internship examines on professional competence).

Connection to the professional demands on the STEM fields. Universities are currently facing an increasing demand for Science, Technology, Engineering and Mathematics graduates (STEM), amidst declining student numbers and averse changes in national funding schemes (van Dorp & Herrero de Egaña Espinosa de los Monteros, 2010). The Environmental Sciences programme studied is, with the computer sciences programmes at the Open Universiteit, the only academic programme in the STEM field. The excellent performance on learning and lifelong learning among VEC participants shows the importance for academic learning in the STEM field. This is not only so from the perspective of professional demands and need in the knowledge society. Students and graduates themselves testify to its importance. In the STEM fields, company supported upgrading of personal careers is too often restricted to management function only, which drives STEM workers out of their profession. Especially the high participation of women in the VEC, with certification among female participants relatively higher (92%, SD 8.5 female; 84%, SD 10.9 male) is of major importance to fulfil the increasing demand for STEM graduates in a – still – male dominated domain. This may suggest that learning in a network suits female students particularly well.

Good performances on lifelong learning of former participants of the VEC model . The high learning and lifelong learning performances on the formal study trajectory VEC – BSc – MSc - (PhD) support the idea that such a model helps to motivate learners to learn during their career. With a score of 88% of the VEC certified student upon enrolment, there is a low drop out. Learning and working in a network, on tasks commissioned by an external client (perhaps a future employer or important network contact in professional career), has a motivating effect. Also the delivery and publishing of the thesis work in the form of an advisory report, increases motivation and self-confidence. In an earlier section, we described the study results in the full BSc programme, with 49% of the enroled students graduating (BSc) within 6 years. Students in the BSc programme, with a background in prior higher education (52%) do better than students (33%) without that (NW, 2013). The high percentages of BSc graduation upon VEC certification show that such a consultancy model could help in motivating and intensiving the study path to BSc graduation. These study results are relatively high compared to other BSc programmes at the Open Universiteit (30 % on the Psychology BSc programme and 13% on the Management Sciences BSc programme (NW, 2013), both programmes reviewed at the same period).

7 Outlook and future research

7.1 Working and learning in the knowledge society: other disciplines

This chapter described a virtual consultancy learning environment in the domain of the environmental sciences and sustainable development. Could the consultancy model be used in disciplines different than environmental sciences and sustainable development, one may plausibly wonder. In the past, after evaluation of the first pilot run of the virtual environmental consultancy (Sluijsmans, Boon, & de Haan, 1998), various other experiences have been reported. The first refer to the general model of a virtual company in computer programming (Bitter-Rijpkema, Sloep, & Jansen, 2003; van Peteghem, Gerrissen, Jansen, Schuwer, & Sloep, 2000; Westera et al., 2000) describe the model applied to an in-service company training at academic level in computer sciences. The model used was not an environmental consultancy but a company department in computer programming. Also, experience was gathered with a virtual environmental consultancy in which the student employees came from various educational institutions and sustainability domains other than the environmental sciences. In the same consultancy model, learners could be involved in advising on various domains to external clients. It did so in the same way current knowledge institutions work - professionals knowledge workers work in temporary mixed project teams on current issues. Examples of these collaboration projects are:

• in the period 2000 – 2004, 28 students of the Maastricht University (Environmental Health BSc programme) (Jansen, Lansu, & Ivens, 2000; Ronteltap & Vesseur, 2002)

• in the academic year 2001/2002, 8 students from Fontys professional programme on applied sciences and 9 students of Twente University (programme of civil engineering and sustainability) (Jansen et al., 2000).

What these projects taught us is that, if each institution itself remains responsible for the final assessment, this kind of collaboration can be quite effective. Its benefit is the low costs on investment. In conclusion, extension to other domains is feasible, although one has to take into account the specificities of the situation (organisation of knowledge actions and support) to which the model has been extended.

7.2 Working and learning in the knowledge triangle: entrepreneurial or innovation skills

We described the model as one in which learners as employees act in the mid of the knowledge triangle. They will be confronted with processes of innovation, which is of eminent importance for a well-functioning regional development (on sustainability initiatives). Further research has started in the context of developing entrepreneurial competences. In a series of research projects funded by the European Life-Long Learning programme, it was found that open distance learning institutions can flexibly involve the adult population to promote entrepreneurship and enterprise creation (van Dorp & Herrero de Egaña Espinosa de los Monteros, 2010). Note that mature adults have relatively high chances to succeed in entrepreneurial activities anyway. The uniqueness of the application of the virtual consultancy model to entrepreneurial activities in the regional ecosystem is that the learner is positioned within the public and private sector on the one hand and in the research sector on the other hand. In the former position learners act both as a working employer and in the consultant role in contact with the client commissioning the research project; in the latter position, learners act both as student researcher on a thesis project on a current topic, and support his fellow student researchers, guided by academic tutors. We already discussed how the use of divergent stakeholder perspectives is vital for dealing with the unstructured sustainability issues. These perspectives also stimulate innovation, essential to strengthening the competitiveness of the region.

One may conclude that the virtual company model may hold promises for stimulating innovation and creative thinking. Much research is needed, though.

7.3 Working and learning in the global society: richness of diversity

Some experience has also been collected with internationally oriented research projects. The client originated from outside the region, with a different language and culture. These are a design study to improve pro-poor sanitation options in Vietnam (van den Wijngaard & Wullaert, 2011); three comparative research projects among Dutch and Argentinean spatial planners commissioned by the Mendoza province in Argentina (van Berkel, Dudink, & Hakkennes, 2007), among Dutch and Swedish regional centres of expertise on sustainable development (Smolder, Spee, & Thys, 2008) and among Dutch, Flemish and German soil remediation expertise (Pals, Perkins, Provoost, & van der Werf, 2000); and some research projects commissioned by a Dutch province as part of a joint collaboration in Rumania (Dhert, van de Ven, & Murrath, 2007; Lengkeek, Poortier, & Wolters-de Baat, 2004).

It might be quite interesting to study the kind of learning that takes place in authentic situations at a global scale: what is the impact of the learner's learning outcomes? Other research questions could focus on the importance of cultural differences in work in virtual teams; or on how the personal and professional development of learners suits with demands on the richness of diversity from networked societies or multinational organisations (van Dam-Mieras et al., 2007).

Obviously, research opportunities abound. However, the limitations and challenges will rise correspondingly. This is perhaps the least clear-cut opportunity for extending the virtual consultancy model. And yet, rewards in terms of impact on sustainable development in a global society might be the largest.

Chapter 6

Conclusions

In this doctorate research we have concentrated on the question how to integrate professional requirements into academic curricula, paying specific attention to quality issues. In our quest to answer this question, we focused on the design and functioning of formal education for lifelong learners, on academic curricula and on courses in formal settings. In doing so, we formulated and subsequently studied two research questions, both pertaining to formal education in particular.

Key words: working and learning, sustainable development, curriculum design, transboundary competence, academic quality assurance

1 Introduction

The present chapter inventories, on the basis of the findings presented in the Chapters 1 to 5, how we can answer these two questions. What now follows is a preview of the rest of the present chapter.

In Section 2, *Learning for sustainable development,* we reflect on the first research question:

1. *How can we design and support learning for sustainable development within the academic organisational system of quality assurance?*

Section 2 summarises the results and achievements formulated throughout the different chapters of this thesis, relevant to this first question.

In Section 3, *Merging professional demands and academic standards in learning for sustainable development,* we follow the same structure, and answer the second research question:

2. *Assuming that education is one of the key drivers for sustainable development and adhering to rigorous academic educational standards and values, is it possible to link learning at academic level to the dynamic practice of the professional demands of regional knowledge societies?*

With the research questions addressed, under the prevailing conditions of the studied case situations, in Section 4 of the present chapter, *Working and learning in a knowledge society,* we elaborate on the problem statement we formulated in the introductory Chapter (1) of this thesis. As we argued there, the following problems arise from working and learning in the knowledge society:

- How might one design and support learning for sustainable development, particularly in the regional knowledge society?
- How may such designs cope with the rapidly changing professional demands from the regional knowledge society pertinent to its innovative power?
- How could learning activities contribute to the acquisition of much needed transboundary competence?

The present chapter then ends with a short description of the virtual consultancy model (Section 5). This rather specific learning design has turned out to be rather successful in the 15 years of its existence, not only in the usual terms of learning efficiency and effectiveness, but also and foremost in providing an answer to the two key research questions of this research (dealt with in Sections 2 and 3 of this chapter respectively). Because of this, a digression is warranted into the question of whether the virtual consultancy model could be used in other, similar kinds of curricula.

2 Learning in a knowledge society

In the present section we reflect on the first research question: How can we design and support learning for sustainable development within the academic organisational system of quality assurance?

The first three chapters of this thesis dealt with this question. They provided a strategy for a curriculum development process in which a curriculum (the programme of courses with its corresponding learning environment) is developed suitable for acquiring transboundary competence for sustainable development.

The curriculum development process starts with the exploration and identification of the characteristics of learning activities, needed to gain competence to work in a professional way in the fast changing environment of sustainable development. This was done in Chapter 2, in which we focussed on the role of universities in sustainable regional development in our increasingly knowledge based society. We concluded that learning for sustainable development could be operationalised as obtaining the ability to cross the boundaries between multiple perspectives in interaction with stakeholders and actors in sustainability issues. This ability, called *transboundary competence*, was clarified in Chapter 2, both conceptually and practically, by introducing an authentic example on the Dutch-Flemish Scheldt Estuary debate on sustainable water management (the Hedwige debate on the managed retreat of coastal defence). We concluded that the didactic models used both at the curriculum level and at the course level within such curriculum designs, have to link to theory in order to allow learners to learn to deal with these different perspectives and to effectively develop their personal competences. The chapter explored how an online remote internship model can effectively support competence development in a professional learning network consisting of people with heterogeneous academic backgrounds.

The second step in the curriculum development process starts with a consultation of the professional field. In Chapter 2 it was described as a curriculum design process. The chapter concluded that such a consultation of networked professionals can indeed be used to derive future job requirements from the contemporary challenges. The consultation of water managers revealed that regional sustainable development asks for a process of mutual, networked learning amongst all actors. This kind of consultation leads to a comprehensive description of the professional demands of sustainable development in society, in terms of challenges, domains, and future job qualifications. The conclusion was drawn that such a consultation process i) helps to fit changing professional demands into academia in a comprehensive way and ii) avoids the derivation of lists of isolated skills and competences. The consultation process therefore supports the ensuing description of transboundary competence as an overall competence goal of academic learning curricula on sustainable development. Transboundary competence is expected to contribute to lifelong learning, in that the learners have learned to take advantage of the cognitive and social dissimilitudes in their professional network and environment. The conclusion is that the strategy to design learning for sustainable development within the academic organizational system of quality assurance, and transboundary competence as a curriculum goal, facilitates the incorporation of knowledge transfer on regional sustainability within the curriculum.

In Chapter 3 we described the third step in the curriculum development process. There we focussed on the enhanced role of universities within the social network of our increasingly knowledge-based society. We concluded that university faculties, with their expertise and experience in learning within the domain, are best suited to and indeed are capable of inferring learning outcomes from the challenges, domains and future job qualifications suggested by the professional network. A design process based on open curriculum development in interaction with the workfield was proposed. The usability of the design process was evaluated through the design of a blended learning Master in Delta Water Management, with again, the cross-border Rhine-Scheldt Delta as the regional level of this study.

Chapter 4 answered the question of how to design and support the learning for sustainable development at course level rather than at the curriculum level of Chapters 2 and 3. The design of courses allows one to reach learning outcomes inferred from the transboundary competence goals. It can be seen as a follow-up on the curriculum development process.

Summarising our findings, we thus answered the first research question on the design and support of the learning for sustainable development with the development of a curriculum development process. This process is described and modelled as a *competence road map*, as an instrument in curriculum development that meets the conditions of quality assurance and changing professional demands. Changes driven by the aim to realise the acquisition of transboundary competence would increase the innovative capacity of study programmes. The findings in this part of our research may help to delineate the main obstacles to implementing the curricula based on sustainable transboundary competences; it may also help to overcome these obstacles.

3 Merging professional demands and academic standards

In this section we try to answer the second research question: Assuming that education is one of the key drivers for sustainable development and adhering to rigorous academic educational standards and values, is it possible to link learning at academic level to the dynamic practice of the professional demands of regional knowledge societies?

The curriculum development process that we described in the previous section already answered the design aspects of this second question. All the steps in this process, from the exploration of the learning characteristics of the domain (Chapter 2), via the consultation of the professional field and the definition of transboundary competence as curriculum competence goals (Chapter 3) and, lastly, the use of a competence road map strategy (Chapter 4) allow one to link learning at an academic level to the dynamic practice of the professional demands of regional knowledge societies. In addition to this, the findings of Chapter 5 lead to an evaluation of this conclusion at course level, based on the learning outcomes realised and the evaluation of the dynamics and performances of learners (see below for more on this).

Learning for sustainable development is learning for change in a domain in which expertise is essential. Knowledge generation and knowledge transfer occur in the interaction of education, research and innovation. There may, however, be more domains than sustainable development, with equally rapidly changing professional demands, in which the curriculum development process can be applied.

In Chapter 5, we discussed the design and the learning activities of the virtual environmental consultancy, a didactic model of a Bachelor-of-Science thesis course in Environmental Sciences. We studied this course in line with the research questions on the main aspects of sustainable development. In what sense did this model allow learners to develop transboundary competence for sustainable development? This research at course level was divided in the following aspects of learning for sustainable development: How does this model help learners to develop themselves (1) into successful professionals in the *knowledge society*; (2) carrying out so-called knowledge actions (in particular as consultants – being a large and growing group of knowledge workers providing services on sustainability initiatives); (3) in *participatory* research and development, bridging the boundaries and controversies between the private and the public domain, and the research sector in the knowledge triangle; and (4) in the multifaceted area of science for sustainability, being confronted with *uncertainties* and with approaches to cope with this lack of knowledge raised from the unknown processes in the earth's system?

Table 6.1. Dutch strengths in scientific disciplines for areas crucial to sustainable development (KNAW, 2012).

Research areas crucial to sustainable development	Scientific disciplines (Dutch strengths) in science for sustainable development
Governance	international institutions, earth system governance, environmental governance, regime shifts, corporate social responsibility, population change and sustainable settlement
Modelling and assessment	climate change, adaptation and mitigation, modelling complex ecosystems, ecological risk assessment, alternative stable states in ecosystems, life cycle assessment and input-output analysis of environmental impacts, ecological modernisation
Water	drinking water and waste water treatment, water management, virtual water footprint, microbiology and biotechnology for water
Energy	biomass gasification and biofuels, impact of biofuels on land use, experience curves in energy, microbiology and biotechnology for energy
Biodiversity	conservation, taxonomy and biogeography, protecting fragile environments
Health and agrofood	socio-economic status and health, infectious diseases, chemical industry, agriculture and sustainability, soil science.

Because sustainable development is affected by the uncertainty of natural processes and phenomena, complexity issues arise in the dimensions of time (future outlook) and geographic scale, as well as in regards to the ecological, economic and social interactions. Many of these elements could be detected in the European Grand Challenges, EU Framework Program in 'Horizon 2020' (European Commission, 2011), or in the Dutch governmental policy of 'top sectors' (Ministerie EL&I, 2011).

The Royal Netherlands Academy of Arts and Sciences, the KNAW (2012) stated that, given the Dutch top sector policy currently being implemented, the scientific orientation on sustainable development in the top sector programmes with the largest potential deserve further enhancement. These are: 1) Water; 2) Energy; 3) Agrofood; 4) Chemistry, and 5) Life Science and Health (Table 6.1).

In summary, we may conclude that we have formulated replies to the two research questions under the prevailing conditions of the cases studied (formal academic learning on water management and environmental sciences). We subsequently explore some new situations, which arise from the problem statement.

4 Working and learning in a knowledge society

This dissertation deals with working and learning at curriculum and course level; we already referred to this. The results of our study at curriculum level have been discussed in Sections 2 and 3 of the present chapter. In this fourth section we elaborate on the problem statement at course level: How, at course level, do we cope with the rapidly changing professional demands from regional knowledge societies pertinent to its innovative power? And: How can learning activities contribute to the acquisition of the competences required?

In Chapter 5, we discussed, at course level, working and learning from the perspective of the didactic model described. This didactic model, the virtual environmental consultancy, was designed as an online company or an environment for remote internships on environmental research issues. This online collaborative work environment has been successful, as is evidenced by the fact that it has been running for 15 years in a row, in which period 187 certificates were awarded. This fact also makes the virtual environmental consultancy unique: published research on such long-term collaborative learning environments is absent in the environmental and sustainable science studies. Over the period 2000-2012, an average of 14 students a year completed their bachelor-of-science thesis research in the context of this model, supported by both clients from the professional field of sustainable development and academics of related scientific disciplines from the university. As the learners in the model work in structured phases of research project management their (intermediate) results were reported, reviewed and assessed at each stage, both their individually produced plans and reflections on personal development, and their virtual work in geo-dispersed teams (professional development). These 15 years of logged knowledge actions constitute a valuable set of data that can be used in the analysis not only for the present dissertation study but probably also beyond that. With these data, answers may potentially be found on how to improve the merging of professional demands and academic standards for topics other than an environmental consultancy for sustainable development, that is, for learning in the knowledge society in general.

The first version of this model, the virtual environmental consultancy, was designed in 1997 and first tested in1998 as a model of a virtual student company. Since then the model has been steadily adapted to the developing demands of time, fuelled also by the evaluation and experiences of pedagogies, tools and technologies, as described in Chapter 5. At the time of writing, the model was still in use (academic year 2012-2013).

In the context of the research aim of this thesis, we focussed on one aspect of the model of the virtual environmental consultancy specifically: we examined how it facilitates learning in the knowledge society and in particular, the development of transboundary competence in the context of learning for sustainable development. Our findings were described in detail in Chapter 5, where we drew general conclusions on its meaning for learning for sustainable development. We also elaborated on some other applications of the model.

5 General description of the online collaborative working environment

In the perspective of working in the knowledge society, virtual consultancy is a company model that is predicated on providing services on research-based (sustainability) issues to society. The staff of this company, learners who are supported by their tutors, can be typified as knowledge workers in view of the complexity of their activities. A virtual consultancy is different than most other companies in several aspects. First, the activity of acquiring competences in line with professional demands is more important than in most other companies. Second, its employees, the learners, work collaboratively in geo-dispersed virtual teams. This implies that the entrepreneurial ecosystem, or economic region, associated with the students and academics of the (regional) higher education institution, is not limited by strict boundaries. Third, the research commissioning clients obtain the results of knowledge-intensive research work for free. Students, tutors and clients are – to some extent – connected to the hinterland region of the university; by social proximity as students combine working, learning and a family; by cognitive proximity, as their professional jobs most likely engendered their interest in the current regional research themes; and by spatial proximity, as the consultancy is a learning environment with blended learning (a combination of daily online interactions and monthly face-to-face interactions, allowing blending of work and learning). Chapter 5 explains the organisation of the virtual environmental consultancy, describes the dynamics and performances of working and learning in such an environment, and refers to the tools and instruments used.

There are several documents available (Ivens et al., 2007; Ivens & Lansu, 2009) that describe the model in detail, for use in one's own educational situation if one so wishes. These guidelines provide information on how the virtual environmental consultancy – or a virtual company in general (Jansen, Slot, & Spoelstra, 2003), is organized, with procedures on learning and assessment, and templates of products and assessments. The learners work collectively to ensure that everyone's expertise is used effectively and at the right time. The availability of such guidelines may strictly speaking not count as a research result of this thesis as they are the result of an effort to produce an effective and innovative learning design. Importantly, though, the claim to the soundness of this design, as described (in Dutch) by the manuals, is directly underpinned by the present research, at least in the context of learning for sustainable development but possibly also beyond that.

Summary

Learning for sustainable development - is learning to come to grips with a fast changing domain in which knowledge is essential. Knowledge generation and knowledge transfer occur in the interaction between education, research and innovation. In this thesis we have researched what this means for future professionals in the field of sustainable development and what the implications are for the design of academic education.

The term sustainable development became widely known in 1987 through the Brundtland-report[3] of the United Nations. It covers our shared future on earth as a living environment, and how this future can be safeguarded for next generations. Sustainable development is multi-faceted. It pertains to the earth as our natural living environment with its natural resources. But it also pertains to making a sustainable future possible, taking into account social equity - as poverty severely limits the choices available - and economic prosperity and its associated cultural values. All these natural phenomena and social processes complicate the pursuit of sustainable development. Through the many perspectives and possible solutions, sustainable development also affects politics and the collaboration between all stakeholders involved.

Though sustainability issues impinge on all geographical levels, from the local to the global, the research in this thesis focuses on the regional level, the level that tends to act as a focal point for economic, social and cultural activities. The regional infrastructure, with its knowledge triangle of public and private parties, as well as higher education, with its research and curricula, play a major role in the search for innovative technological and creative institutional solutions for a sustainable society.

[3] The title of this report is Our Common Future, the then Norwegian prime-minister Gro Harlem Brundtland chaired the United Nations World Commission on Environment and Development.

The complex interplay of natural, social and political factors makes learning and teaching about sustainable development a tall order. Therefore, the first research question we address is:

1. How may one design and support learning for sustainable development within the academic organisational system of quality assurance?

We address this issue from the perspective of the curriculum. We investigate the approach of merging the demands of the professional field with the standards in academic education, as is reflected in the subtitle of this thesis*: Merging professional demands and academic standards.*

In particular, we focus on the question of how one may acquire the competences needed for jobs related to sustainable development, and how those competences may be taught. We assume that the future professional in sustainable development must acquire *transboundary competence.* This competence refers to the ability to communicate and collaborate across traditional boundaries between disciplines and perspectives, by working in interaction with diverse actors and stakeholders. Hence it is a multi-perspective competence, one that reflects the nature of sustainability science.

Sustainable development thus essentially unites a variety of perspectives, including those of academics and professionals. This brings us to the second research question:

2. Assuming that education is one of the key drivers for sustainable development and adhering to rigorous academic educational standards and values, is it possible to link learning at academic level to the dynamic practice of the professional demands of regional knowledge societies?

We addressed this research question by investigating how to design curricula and courses that incorporated the demands of the professional workfield and sought practical applications. We used the context of formal academic education for lifelong learners. The case studies we researched concerned curricula in delta water management in the Rhine-Scheldt estuary (Chapter 2 and 3) and in environmental sciences (Chapter 4 and 5). A specific case study related to a didactic model (Chapter 5), the virtual environmental consultancy, in which students, as part of their bachelor-of-science thesis, work on authentic assignments from the dynamic professional workfield.

The thesis comprises four exploratory studies; each focuses on a different aspect of learning for sustainable development. The four exploratory studies (Chapters 2 to 5) focus in particular on the design requirements for a learning environment that should prepare students to work on sustainable development. We discuss in detail how these requirements can be translated into the design of curricula and learning environments, which should at the same time be sufficiently robust to cope with the changing professional demands. The guidelines resulting from this exercise can be used in the practice of academic learning for sustainable development.

In **Chapter 1** we describe the pitfalls and barriers of linking theory to practice in academic learning, particularly in the area of sustainable development. Based on existing literature, we describe the multiple perspectives with which this issue can be viewed. We identify three dimensions of relevance:

The first – cognitive - dimension is based on the characteristics of both knowledge work and the work on sustainable development. We conclude that the broad domain of sustainable development can be regarded as *knowledge work*. Working towards sustainable development implies diagnostic- and solution-oriented research. These are also characteristics of knowledge work and require interaction between research and society at academic level. The second - social - dimension of sustainable development, implies *participatory interaction* between universities or research institutions and public and private parties in society. This implies making use of the divergent stakeholder perspectives. The third dimension, *uncertainty*, is strongly connected with the natural processes and phenomena of the earth system.

In **Chapter 2** we demonstrate the complexity of the concept of sustainable development, and show that learning for sustainable development and the competence to be acquired, is not easy. The example described, the Dutch-Flemish Scheldt estuary debate (on the managed retreat of coastal defences at the Hedwige polder) illustrates these different perspectives as well as their effect on the scientific domain of decision-making on sustainability issues. We describe a didactic model in which students in virtual teams can work on these kind of current and authentic research assignments. These assignments are commissioned by clients, the students' future employers.

We define the learning of students in this model as remote internships (thesis research), which after analysis in Chapter 5, is further defined as consultancy, hence a kind of knowledge work. This form of learning emphasises the role of the learners as agents interacting with the knowledge triangle: the network of the clients' workfield, the academic community through the tutors and the professional network contacts of their fellow students. The analysis of the learner characteristics, described in this chapter 2, show the importance of heterogeneity between students, the flexibility in personal and professional development and the participatory interaction, as a prerequisite to acquire transboundary competence. Although our focus is on formal learning, there is a striking resemblance with networked learning, a means to support knowledge workers throughout their careers in their need for non-formal learning.

In **Chapter 3** we describe how transboundary competence for sustainable development can be embedded in a vision on learning and curriculum development, thus ensuring the academic quality of learning. We present a design for open curriculum development that implies openness to the professional demands from the domain and adheres to academic quality standards. In the first step of the design process, professional experts define in consensus workshops, future challenges. In the second step, they outline candidate profiles apt to tackle these challenges. A pre-structured job advert template, structured to the academic quality criteria for higher education (European 'Dublin' Descriptors), has been used to articulate desired qualifications and experiences. These resulted in a renewed definition of the professional, transboundary competence. The moderators of the process are able to incorporate surreptitiously the complex (national) qualification framework for university programmes, often seen as an obstacle for open curriculum development.

In **Chapter 4** we discuss a design strategy for open curriculum development. The strategy fits learning at an academic level – with its standards and values – to the changeable practices for sustainable development that emerge from innovative regional development. The design of a competence roadmap allows for the development of a (university-level) curriculum bound by both the conditions of academic quality assurance and the changing professional demands, taking the 'proficiency of the working environmental professional' as a curriculum goal. The application of the design strategy to a BSc and an MSc study in Environmental Sciences resulted in the development of three areas of competence - diagnosis, research and intervention. They sit at the core of both programmes. The methodology of the design strategy aims to be a method for fine-tuning the communication between the different institutional systems and traditions of scholars and professionals.

Chapter 5 reports on the design, dynamics and performances of learning and working in virtual teams on consultancy, in a formal, academic setting: the virtual environmental consultancy (VEC) of the Open Universiteit (OUNL) in the Netherlands. Labour markets increasingly demand high levels of expertise, implying that novices (academics) should also be able to take up complex tasks easily. This, in turn, challenges universities to design learning environments that allows students not only to gain knowledge but also to practice the expected professionals attitudes, i.e. to become competent. Our findings support the conclusion that, broadly speaking, a virtual consultancy model fully suits the professional demands and learning opportunities for knowledge workers. Heterogeneity in learning teams helps to develop transboundary competence in learners, to aid them in solving 'non-routine' problems. The virtual consultancy model allows for heterogeneity in age, gender and nationality (although our experience is restricted to Dutch speaking Belgian and Dutch participants). The model also accommodates heterogeneity in professional and educational background, which implies a rich environment of professional and disciplinary expertise.

Although the measurement of performances in collaborative learning models is complex, the results of the VEC data explored support the finding that i) the mean study time is similar to the planned study time, but ii) will differ strongly over the years and between individuals. The latter finding is conducive to a high pace of study in open distance learning. Over the academic years learning performances are good and fairly equal among female and male students. The percentage of certification (87%, SD 8.4) supports the finding of a good learning performance, at least in open distance learning. Good performance in lifelong learning of former participants of the VEC model furthermore supports the idea that such a model helps to motivate learners to continue learning during their subsequent careers. All of the BSc-thesis research subjects (2000-2012) studied by the students in their consultancy teams, match perfectly the key domains of research and innovation (European Horizons) in science for sustainable development. The consultancy model, with its increase of the number and in complexity of knowledge actions during the learning trajectory, supports future environmental scientists in their role as knowledge worker on complex sustainability issues.

By mutually connecting the findings of the Chapters 2 to 5, **Chapter 6**, answers the two research questions formulated in Chapter 1.

Samenvatting

Leren voor duurzame ontwikkeling – *Learning for sustainable development* - is een vorm van leren bedoeld om vat te krijgen op een snel veranderend domein waarin kennis essentieel is. Die kennisontwikkeling en kennisoverdracht gebeurt in wisselwerking met onderwijs, onderzoek en innovatie. In dit proefschrift hebben we, vanuit het perspectief van academisch onderwijs, onderzocht wat dit betekent voor het opleiden van toekomstige professionals in het werkveld van duurzame ontwikkeling en wat daarbij de implicaties zijn voor het ontwerpen van academisch onderwijs.

Het begrip duurzame ontwikkeling is rond 1987 wereldwijd bekend geworden door het Brundtland-rapport[4] van Verenigde Naties. Het gaat over onze gezamenlijke toekomst en hoe we die toekomst, met de aarde als leefomgeving, veilig kunnen stellen voor toekomstige generaties. Duurzame ontwikkeling heeft vele gezichten. Het gaat over de aarde als onze natuurlijke leefomgeving met haar hulpbronnen. Maar duurzame ontwikkeling heeft eveneens betrekking op het mogelijk maken van een duurzame toekomst, rekening houdend met sociale rechtvaardigheid want in armoede kun je geen keuzes maken en om economische welvaart en de daarmee verbonden culturele waarden. Al deze natuurlijke en sociale processen en fenomenen compliceren het streven naar duurzame ontwikkeling. Door de vele perspectieven en mogelijke oplossingsrichtingen hebben duurzaamheidsvraagstukken ook invloed op de politiek en op de samenwerking tussen alle betrokken partijen.

Hoewel duurzaamheid van invloed is op alle geografische niveaus, van lokaal tot mondiaal, richt het onderzoek in dit proefschrift zich op het regionale niveau, het niveau waarop economische, sociale en culturele activiteiten samenkomen. Een

[4] De titel van dit rapport is Our Common Future, de toenmalige Noorse premier Gro Harlem Brundtland was voorzitster van de World Commission on Environment and Development, van de Verenigde Naties.

belangrijke rol in het zoeken naar innovatieve technologische en creatieve oplossingen voor een duurzame samenleving is hierbij weggelegd voor de regionale samenwerking in de kennisdriehoek: de publieke en private partijen en het hoger onderwijs met haar onderzoek en onderwijs.

Dat complexe samenspel van natuurlijke, sociale en politieke factoren maakt het onderwijzen en het leren voor duurzame ontwikkeling een hele opgave. De eerste onderzoeksvraag waar we ons op richten is daarom:

1. Hoe kunnen we het leren voor duurzame ontwikkeling ontwerpen en ondersteunen binnen de academische organisatorische systeem van kwaliteitszorg?

We doen dit vanuit het perspectief van de opleiding. De oplossing zoeken we in het samenvoegen van de eisen die voortkomen uit het werkveld met de normen uit het academisch onderwijs. De ondertitel van dit proefschrift duidt hier ook op*: Merging professional demands and academic standards.*

In het bijzonder, richten we ons op de vraag hoe je competent kunt worden voor functies en taken op het gebied van duurzame ontwikkeling, en hoe kun je de benodigde competenties daarvoor kunt verwerven. We gaan er daarbij vanuit dat de toekomstige professional in duurzame ontwikkeling over *transboundary competence* moet beschikken; het vermogen moet hebben om kritisch te denken, te communiceren, te leren en samen te werken over de grenzen heen die de perspectieven verdelen. Daarom is het een competentie met meerdere perspectieven, die hiermee de aard van de duurzaamheidswetenschap (‘sustainability science’) weerspiegelt.

Duurzame ontwikkeling verenigt dus in wezen een aantal perspectieven, inclusief die vanuit de academische wereld en die vanuit het werkveld. Dit brengt ons bij de tweede onderzoeksvraag:

2. Als we ervan uitgaan dat onderwijs een van de belangrijke drijfveren is voor duurzame ontwikkeling en zich moet houden aan strikte academische waarden en kwaliteitseisen, kan leren op academisch niveau dan worden gekoppeld aan de dynamische praktijk van de professionele eisen die vanuit de regionale kennissamenleving worden gesteld?

In de zoektocht naar een antwoord op deze onderzoeksvraag onderzochten we, hoe curricula en cursussen zijn te ontwerpen die voldoen aan de vraag vanuit het professionele werkveld en hoe het uiteindelijk werkt in de uitvoering. Dit deden we binnen de context van formeel academische onderwijs voor levenlang lerenden: aan de hand van case studies over curricula gericht op watermanagement in het Deltagebied (hoofdstuk 2 en 3) en de milieuwetenschappen (hoofdstuk 4 en 5). Eén case study betreft gaan curriculum, maar een onderwijsvorm (hoofdstuk 5): het virtueel milieuadviesbureau, waarin studenten als BSc-afstudeeronderzoek werken aan authentieke opdrachten uit die dynamische praktijk van het werkveld.

Het proefschrift bestaat uit vier verkennende studies, elk gericht op een ander aspect van het leren voor duurzame ontwikkeling. De vier verkennende studies (hoofdstukken 2 tot en met 5) richten zich met name op de ontwerpeisen voor een leeromgeving die studenten moet voorbereiden op het werken aan duurzame ontwikkeling. We bespreken in detail hoe deze eisen kunnen worden vertaald in het ontwerp van curricula en leeromgevingen. Deze moeten tegelijkertijd voldoende robuust zijn om met de veranderende vraag vanuit het werkveld om te kunnen gaan. Uit deze exercitie volgen richtlijnen die in de praktijk van academische leren voor duurzame ontwikkeling gebruikt kunnen worden.

In **hoofdstuk 1** beschrijven we de valkuilen en barrières, die het verbinden van theorie en praktijk in het academisch leren met zich meebrengt, in het bijzonder op het gebied van duurzame ontwikkeling. Op basis van bestaande literatuur beschrijven we de verschillende perspectieven waarmee dit probleem kan worden bekeken. We identificeren drie dimensies die van belang zijn:

De eerste - cognitieve - dimensie is gebaseerd op de kenmerken van zowel kenniswerk als het werken aan duurzaamheidsvraagstukken. We concluderen dat het brede domein van duurzame ontwikkeling kan worden beschouwd als *kenniswerk ('knowledge work').* Werken aan duurzame ontwikkeling veronderstelt diagnostisch- en oplossingsgericht onderzoek. Dit zijn tegelijkertijd ook de kenmerken van kenniswerk en deze vereisen interactie tussen onderzoek en maatschappij op academisch niveau. De tweede - sociale - dimensie van duurzame ontwikkeling, impliceert *participatieve interactie ('participatory interaction')* tussen universiteiten of onderzoeksinstellingen, en de publieke en private partijen in de samenleving. Dit houdt in dat gebruik gemaakt wordt van de uiteenlopende belangen. De derde dimensie, onzekerheid ('*uncertainty'*), is sterk verbonden met de natuurlijke processen en verschijnselen van het systeem aarde.

In **hoofdstuk 2** laten we de complexiteit van het concept duurzame ontwikkeling zien. Bovendien laten we zien dat leren voor duurzame ontwikkeling en het verwerven van de bijbehorende competentie niet eenvoudig is. Het beschreven voorbeeld, het Nederlands-Vlaamse debat over de voorgenomen ontpoldering van de Zeeuwse Hedwigepolder (in het Schelde estuarium), illustreert deze verschillende perspectieven. Het laat ook zien welk effect deze verschillende perspectieven hebben op het wetenschappelijke domein van de besluitvorming over duurzaamheid. We beschrijven een didactisch model waarin studenten in virtuele teams kunnen werken aan dit soort actuele en authentieke onderzoeksopdrachten. Deze opdrachten komen van opdrachtgevers uit het werkveld, de toekomstige werkgevers van deze studenten.

We definiëren het leren van studenten in dit model als 'remote internschips' (afstudeerstages op afstand), die in hoofdstuk 5, na analyse, verder worden gedefinieerd als een consultancy-werkvorm en daarmee zijn te typeren als een vorm van kenniswerk . Deze vorm van leren benadrukt de rol van de studenten als actoren en beslissers in interactie met de partijen in de kennisdriehoek: via de opdrachtgever met het netwerk van het werkveld van die opdrachtgever, via de begeleidend docenten met de academische gemeenschap en via de medestudenten met de professionele netwerkcontacten van deze studenten. Uit de analyse van de studentkenmerken, zoals beschreven in hoofdstuk 2, blijkt het belang van heterogeniteit tussen de studenten onderling, de flexibiliteit in persoonlijke en professionele ontwikkeling en de participatieve interactie, als een voorwaarde om 'transboundary competence' te verwerven. Hoewel onze focus zich richt op formeel leren, is er een opvallende gelijkenis met netwerkleren, dat een hulpmiddel is om kenniswerkers tijdens hun loopbaan te ondersteunen in hun behoefte aan niet-formeel leren.

In **hoofdstuk 3** beschrijven we hoe 'transboundary competence' voor duurzame ontwikkeling kan worden ingepast in een visie op leren en curriculumontwikkeling, waarbij de academische kwaliteit van het leren blijft gegarandeerd. We presenteren een ontwerp voor open curriculumontwikkeling dat openheid impliceert naar de professionele eisen vanuit het domein en dat voldoet aan de academische kwaliteitsnormen. In de eerste stap van het ontwerpproces, definiëren professionals de toekomstige uitdagingen in het veranderend werkveld, met behulp van workshops gericht op consensus. In de tweede stap van het ontwerpproces, schetsen deze professionals gezamenlijk de profielen voor toekomstige kandidaten deze toekomstige uitdagingen aan zouden kunnen pakken. Om de gewenste kwalificaties en ervaringen te verwoorden is een voorgestructureerd sjaboon voor vacatureteksten gebruikt. De gehanteerde structuur in dat sjabloon is afgeleid van de structuur waarmee de academische kwaliteitscriteria voor het hoger onderwijs (de Europese 'Dublin' descriptoren) zijn beschreven. Het ontwerpproces resulteert hierdoor in een vernieuwde definitie van de professionele ‘transboundary competence’. De moderatoren van het proces kunnen op deze wijze ongemerkt het complexe (nationale) kwalificatiekader voor universitaire opleidingen hanteren, terwijl dat vaak gezien wordt als een obstakel voor een open curriculumontwikkeling.

In **hoofdstuk 4** bespreken we een ontwerpstrategie voor open curriculumontwikkeling. Doel van die strategie is om het leren op academisch niveau - met zijn normen en waarden - aan te laten sluiten op de veranderende praktijk voor duurzame ontwikkeling, voortkomend uit innovatieve ontwikkelingen in de regio. Het ontwerp van een ’competence roadmap’ als leidraad zorgt voor de ontwikkeling van een (universitair niveau) curriculum dat gebonden is aan zowel de voorwaarden van academische kwaliteitsborging als aan de veranderende professionele eisen uit het werkveld. Hierbij is het werkniveau van de milieu-professional als curriculumdoel geformuleerd. De toepassing van deze ontwerpstrategie op een BSc en een MSc studieprogramma in de milieuwetenschappen (‘Environmental Sciences’) heeft geleid tot de ontwikkeling van drie competentiegebieden - diagnose, onderzoek en interventie. Deze competentiegebieden vormen de kern van beide programma's. De ontwerpstrategie beoogt een methode te zijn waarmee de communicatie tussen de verschillende institutionele systemen en tradities, van enerzijds wetenschappers en anderzijds professionals uit het werkveld, op elkaar kan worden afgestemd.

In **hoofdstuk 5** rapporteren we over het ontwerp, de dynamiek en de prestaties van het leren & werken in virtuele teams in consultancy, binnen een formele, academische setting: het *virtueel milieuadviesbureau* (VEC) van de Open Universiteit (OUNL). De arbeidsmarkt vraagt steeds vaker om een hoog niveau van expertise, wat betekent dat starters (academici) op de arbeidsmarkt ook complexe taken op zich kunnen nemen. Dit zorgt voor een uitdaging voor de universiteiten: om leeromgevingen te ontwerpen, waarbij de studenten niet alleen de mogelijkheid hebben om kennis op te doen, maar waarbij ze ook de verwachte professionals houding kunnen oefenen om hierdoor competent te kunnen worden. Onze bevindingen ondersteunen de conclusie dat, in grote lijnen, een virtuele consultancy model volledig aansluit op de professionele eisen die het werkveld stelt aan kenniswerkers en de leermogelijkheden van kenniswerkers. Het blijkt dat heterogeniteit in lerende teams van studenten de lerenden ondersteunt bij het ontwikkelen van deze 'transboundary competence. Het helpt hen bij het oplossen van 'non-routine' problemen (die geen routinewerk vergen). Het virtuele consultancy model geeft de mogelijkheid om heterogeniteit in leeftijd, geslacht en nationaliteit in te brengen in het leren (alhoewel de studie zich beperkt tot Nederlandstalige deelnemers uit België en Nederland). Het model geeft ook de mogelijkheid tot heterogeniteit in professionele en educatieve achtergrond van studenten. Hierdoor ontstaat een rijke omgeving van expertises uit het werkveld en het vakgebied.

Hoewel het meten van prestaties in modellen voor samenwerkend leren complex is, ondersteunen de resultaten van de VEC data die zijn verkend (uit de academische studiejaren 2000-2012), de conclusie dat 1) de gemiddelde, gerealiseerde studietijd vergelijkbaar is met de geplande studietijd (model), maar 2) sterk zal verschillen over de jaren heen en tussen individuen. Deze bevindingen laten zien dat het gebruik van een virtueel consultancy-model een hoog studietempo in open afstandsonderwijs bevordert. Over de studiejaren heen zijn de leerprestaties goed en lopen deze behoorlijk gelijk als we de vrouwelijke en mannelijke studenten vergelijken.

Het hoge percentage gecertificeerden (87%, SD 8,4) ondersteunt de resultaten die laten zien dat er goede leerprestaties worden geleverd, in ieder geval voor open afstandsonderwijs. De goede prestaties van oud-deelnemers aan het virtueel milieuadviesbureau (VEC) in levenslangleren ondersteunt bovendien het idee dat een dergelijk model helpt om lerenden te motiveren om te blijven leren tijdens hun latere loopbaan. Alle BSc- onderzoeksonderwerpen (2000-2012) die de studenten in hun consultancy-teams hebben bestudeerd, sluiten perfect aan op de belangrijkste domeinen van onderzoek en innovatie (Europese Horizons) binnen het wetenschappelijk domein van duurzame ontwikkeling. Het consultancy model laat gedurende het leertraject een toename zien in het aantal en de complexiteit van kennisacties. Dit ondersteunt toekomstige milieuwetenschappers in hun rol als kenniswerker op complexe duurzaamheidsvraagstukken.

In **hoofdstuk 6** zijn de twee onderzoeksvragen, die in hoofdstuk 1 waren geformuleerd, beantwoord door de resultaten uit de hoofdstukken 2 tot en met 5 onderling met elkaar in verband te brengen.

Curriculum Vitae

Ir. Angelique Lansu (1963, Vlissingen, the Netherlands) works currently as lecturer in earth sciences at the School of Science (faculteit Natuurwetenschappen) of the Open Universiteit, the Netherlands. Her doctorate (PhD) research, reported in this thesis, was conducted at the same university under the aegis of the UNESCO Chair in *Knowledge Transfer for Sustainable Development Supported by ICTs* (prof. dr. Rietje van Dam-Mieras), established at the Open Universiteit's School of Science, and under the auspices of the Centre for Learning Sciences and Technologies (CELSTEC), Chair Technology Enhanced Learning (prof. dr. Peter B. Sloep) also at the Open Universiteit. Co-supervisor Jo Boon, who handled daily support, is associate professor learning sciences at CELSTEC with research interests encompassing competency management, informal learning and learning related to work and employability.

Angelique Lansu has over 20 years of expertise in learning design, curriculum development and management of funded projects, resulting in e-learning environments. At the OU, she developed and coordinates a number of interdisciplinary and innovative courses on the earth sciences and sustainable development, always in close collaboration with colleagues from the OUNL and experts of European and South American partner universities. Besides several course books and e-workbooks, examples are multimedia serious games on environmental soil science soil & water management, the virtual environmental consultancy, online practicals on geo information systems and online seminars on sustainability. Research interest is on how learners could become competent for sustainable development in the knowledge society, with emphasis on networked learning in geo-dispersed virtual teams and on internationalisation in e-learning curricula.

She was trained at Wageningen University, NL (MSc, 1988) with majors in tropical soil science and in geomorphology and minors in developmental economics and in soil physics. She worked on student research projects on sustainable land use in South-America

(Colombia, Costa Rica). After graduation, she has worked as a lecturer in soil & environmental studies (van Hall Institute, Leeuwarden, NL) before she joint the Open Universiteit in 1990.

Dankwoord

Leren voor duurzame ontwikkeling – *Learning for sustainable development* – is een vorm van leren bedoeld om vat te krijgen op een snel veranderend domein waarin kennis essentieel is. Die kennisontwikkeling en kennisoverdracht gebeurt in wisselwerking met onderwijs, onderzoek en innovatie. Dat is ook precies de omgeving waarin dit proefschrift tot stand kwam: het ontwerpen van onderwijs, de vertaling naar de onderwijspraktijk en het onderzoeken hoe het uiteindelijk werkt in de uitvoering is alweer meer dan 22 jaar mijn dagelijks werk als universitair docent aardwetenschappen aan de Open Universiteit. Maar voor het schrijven van een proefschrift is meer nodig dan gewoon goed je werk doen. Gelukkig kreeg ik hierbij steun, hulp en ook de broodnodige afleiding van heel veel mensen om mij heen. Dat is het grote voordeel van promoveren bij je eigen werkgever. De mensen om je heen zijn goede bekenden en lieve vrienden, en de mens heeft nu eenmaal de neiging de groep mensen om zich heen anders te behandelen dan vreemden (Arnon Grunberg noemt dit het maffiaprincipe[5]). Dat geluk viel mij ten deel en ik heb ervan genoten. Er zijn er maar een paar die ik met naam noem, alle anderen – even dierbaar – hoop ik persoonlijk te kunnen bedanken.

Dit proefschrift heeft zijn oorsprong op een stationnetje 's morgens in de vroegte, ergens aan de voet van de Andes in Chili, in het voorjaar van 2006. Rietje gaat naast mij op het wachtbankje zitten en pakt haar schrijfblok. We komen net terug uit een kuuroord, ergens afgelegen in de bergen, waar we een hele week intensief gewerkt hebben aan een internationaal MSc-programma

[5] Arnon Grunberg noemt dit het maffiaprincipe (vk, 12/1/13) naar aanleiding van een artikel van de filosoof Stephen T. Asma *De mythe van universele liefde* (New York Times).

sustainable development, met partners van universiteiten in Zuid-Amerika en Europa. Al snel staat een hoofdstukindeling op papier: het zal gaan over Learning for sustainable development, e-learning en internationalisering. Uiteindelijk heeft het een hele tijd geduurd voordat het boekje een start kreeg en heeft het een heel andere focus gekregen, maar de onvoorwaardelijke steun van Rietje bleef. Ook in de tijd dat ze vice-rector van de universiteit Leiden was en later vanuit Campus Den Haag en vanuit Cadzand als thuisbasis hield ze als een echte promotor steeds de focus scherp. Heel erg bedankt, Rietje.

Misschien lag de oorsprong van dit boekje nog wel veel eerder. De lol in het ontwerpen en ontwikkelen van onderwijs met nieuwe tools moet ook gefaciliteerd worden. Op mijn allereerste dag op de OU, op 3 september 1990, kreeg ik van Peter Sloep, destijds mijn collega bij Natuurwetenschappen, een prachtig klein Apple-computertje op mijn bureau, met de opdracht er maar eens een paar dagen van alles mee uit te proberen. Ik kreeg een gouden tip van hem mee, die ik nog altijd hanteer: alles wat je zelf bedenkt wat zou moeten kunnen op een computer is mogelijk; je moet alleen even uitzoeken hoe. Ik had toen nog niet bedacht hoe snel dit avontuur zich zou uitbreiden. Een paar jaar later keek ik met Peter en Darco Jansen mee op het eerste internet, en nog wat later – toen de VB groep een plan voor een virtueel werk- en leerbedrijf uitwerkte – bedachten we met Wim Westera in 1997 een milieuadviesbureau in een online vorm. Dat dit daardoor 15 jaar later nog steeds als online wonder kan worden beschreven, leest u in hoofdstuk 5. Het was heel fijn dat Peter, intussen hoogleraar Technology enhanced learning bij CELSTEC, het zag zitten om mij te begeleiden. Ook al was dit de laatste weken hectisch, ’s avonds laat en met nog te veel open einden van mijn kant. Hartelijk dank voor alle inzet!

En dan Jo. Met haar heb ik niet zo’n uitgebreid verleden als met Rietje en Peter. Natuurlijk kende ik Jo van de OU, maar ik had nog nooit met haar samengewerkt. Het klikte meteen in onze eerste brainstorm over het ontwerp voor een cursus voor Benin. Niet veel later werd Jo mijn ‘dagelijks’ begeleider, uitverkoren uit de leerstoel-groep van Peter. Ik was er blij mee, de Vlaamse klankkleur voelde meteen als thuis. En wat al snel bleek: we konden beiden als het moest heel hard werken maar ook heel erg veel lachen. Het was ook een heel avontuur, de combinatie van alle know-how die Jo heeft op het gebied van de onderwijswetenschappen met het aardwetenschap-pelijk veldwerk wat ik losliet op de studentendata. Als er weer eens van mijn hand een landkaartje of diagram verscheen in plaats van een degelijk stukje tekst, zag ik Jo genieten. En zorgen maken. En toch is het boekje er gekomen. Jo, heel erg bedankt voor de fantastische samenwerking die vast nog even door zal gaan. Heel erg bedankt voor al je warmte en hartelijkheid.

Na deze dankwoorden aan mijn twee promotoren Rietje en Peter en mijn co-promotor Jo, gaat mijn dank uit naar de sparringpartners in mijn eigen clubje, de faculteit Natuurwetenschappen.
Met Ansje Löhr en Daisy Tysmans hebben we in het water-management een werkelijk Luctor et Emergo behaald. Hoogtepunt met Ansje was natuurlijk onze gefilmde boottocht op het KNAW-NIOO meetschip de Luctor, de Schelde op- en afvarend. Uitzending gemist? Geen probleem, delen van de filmpjes zijn vast onderdeel geworden van de multimediacases Scheldt, over het hoe en waarom van ontpoldering, en die door de dames Daisy, Ansje en Angelique met pizza zijn vastgelegd in serious gaming software, jawel, Emergo genaamd. Voor al het bodem- & waterplezier met Daisy heb ik nog een klein Vlaams quizje achtergelaten in dit boekje. Waar is de Hollandse Loes?

Maar natuurlijk gaat er niets boven de samenwerking met Wilfried Ivens. Los nog even van het feit dat hij de enige overgebleven OU-er is van de sollicitatiecommissie die mij heeft aangenomen (met Wim, Aad, Jef en Marthie), is hij degene die in ieder hoofdstuk een rol speelt door het werk wat we er samen aan hebben gedaan. Altijd met veel plezier! TNX!

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Gelukkig heeft alleen de totstandkoming van dit boekje moeten lijden onder mijn werk, jullie niet ;-)

Angelique Lansu

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